THE

POPULAR SCIENCE MONTHLY.

NOVEMBER, 1877.

ILLUSTRATIONS OF THE LOGIC OF SCIENCE.

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FIRST PAPER.—THE FIXATION OF BELIEF.

I.

FEW persons care to study logic, because everybody conceives himself to be proficient enough in the art of reasoning already. But I observe that this satisfaction is limited to one's own ratiocination, and does not extend to that of other men.

We come to the full possession of our power of drawing inferences the last of all our faculties, for it is not so much a natural gift as a long and difficult art. The history of its practice would make a grand subject for a book. The mediæval schoolmen, following the Romans, made logic the earliest of a boy's studies after grammar, as being very easy. So it was, as they understood it. Its fundamental principle, according to them, was, that all knowledge rests on either authority or reason; but that whatever is deduced by reason depends ultimately on a premise derived from authority. Accordingly, as soon as a boy was perfect in the syllogistic procedure, his intellectual kit of tools was held to be complete.

To Roger Bacon, that remarkable mind who in the middle of the thirteenth century was almost a scientific man, the schoolmen's conception of reasoning appeared only an obstacle to truth. He saw that experience alone teaches anything—a proposition which to us seems easy to understand, because a distinct conception of experience has been handed down to us from former generations; which to him also seemed perfectly clear, because its difficulties had not yet unfolded themselves. Of all kinds of experience, the best, he thought, was interior illumination, which teaches many things about Nature

which the external senses could never discover, such as the transubstantiation of bread.

Four centuries later, the more celebrated Bacon, in the first book of his "Novum Organum," gave his clear account of experience as something which must be open to verification and reëxamination. But, superior as Lord Bacon's conception is to earlier notions, a modern reader who is not in awe of his grandiloquence is chiefly struck by the inadequacy of his view of scientific procedure. That we have only to make some crude experiments, to draw up briefs of the results in certain blank forms, to go through these by rule, checking off everything disproved and setting down the alternatives, and that thus in a few years physical science would be finished up—what an idea! "He wrote on science like a Lord Chancellor," indeed.

The early scientists, Copernicus, Tycho Brahe, Kepler, Galileo, and Gilbert, had methods more like those of their modern brethren. Kepler undertook to draw a curve through the places of Mars;[1] and his greatest service to science was in impressing on men's minds that this was the thing to be done if they wished to improve astronomy; that they were not to content themselves with inquiring whether one system of epicycles was better than another, but that they were to sit down to the figures and find out what the curve, in truth, was. He accomplished this by his incomparable energy and courage, blundering along in the most inconceivable way (to us), from one irrational hypothesis to another, until, after trying twenty-two of these, he fell, by the mere exhaustion of his invention, upon the orbit which a mind well furnished with the weapons of modern logic would have tried almost at the outset.

In the same way, every work of science great enough to be remembered for a few generations affords some exemplification of the defective state of the art of reasoning of the time when it was written; and each chief step in science has been a lesson in logic. It was so when Lavoisier and his contemporaries took up the study of chemistry. The old chemist's maxim had been, "*Lege, lege, lege, labora, ora, et relege.*" Lavoisier's method was not to read and pray, not to dream that some long and complicated chemical process would have a certain effect, to put it into practice with dull patience, after its inevitable failure to dream that with some modification it would have another result, and to end by publishing the last dream as a fact: his way was to carry his mind into his laboratory, and to make of his alembics and cucurbits instruments of thought, giving a new conception of reasoning, as something which was to be done with one's eyes open, by manipulating real things instead of words and fancies.

The Darwinian controversy is, in large part, a question of logic. Mr. Darwin proposed to apply the statistical method to biology. The same thing had been done in a widely different branch of science, the

[1] Not quite so, but as nearly so as can be told in a few words.

theory of gases. Though unable to say what the movements of any particular molecule of a gas would be on a certain hypothesis regarding the constitution of this class of bodies, Clausius and Maxwell were yet able, by the application of the doctrine of probabilities, to predict that in the long run such and such a proportion of the molecules would, under given circumstances, acquire such and such velocities; that there would take place, every second, such and such a number of collisions, etc.; and from these propositions were able to deduce certain properties of gases, especially in regard to their heat-relations. In like manner, Darwin, while unable to say what the operation of variation and natural selection in any individual case will be, demonstrates that in the long run they will adapt animals to their circumstances. Whether or not existing animal forms are due to such action, or what position the theory ought to take, forms the subject of a discussion in which questions of fact and questions of logic are curiously interlaced.

II.

The object of reasoning is to find out, from the consideration of what we already know, something else which we do not know. Consequently, reasoning is good if it be such as to give a true conclusion from true premises, and not otherwise. Thus, the question of its validity is purely one of fact and not of thinking. A being the premises and B the conclusion, the question is, whether these facts are really so related that if A is B is. If so, the inference is valid; if not, not. It is not in the least the question whether, when the premises are accepted by the mind, we feel an impulse to accept the conclusion also. It is true that we do generally reason correctly by nature. But that is an accident; the true conclusion would remain true if we had no impulse to accept it; and the false one would remain false, though we could not resist the tendency to believe in it.

We are, doubtless, in the main logical animals, but we are not perfectly so. Most of us, for example, are naturally more sanguine and hopeful than logic would justify. We seem to be so constituted that in the absence of any facts to go upon we are happy and self-satisfied; so that the effect of experience is continually to contract our hopes and aspirations. Yet a lifetime of the application of this corrective does not usually eradicate our sanguine disposition. Where hope is unchecked by any experience, it is likely that our optimism is extravagant. Logicality in regard to practical matters is the most useful quality an animal can possess, and might, therefore, result from the action of natural selection; but outside of these it is probably of more advantage to the animal to have his mind filled with pleasing and encouraging visions, independently of their truth; and thus, upon unpractical subjects, natural selection might occasion a fallacious tendency of thought.

That which determines us, from given premises, to draw one inference rather than another, is some habit of mind, whether it be constitutional or acquired. The habit is good or otherwise, according as it produces true conclusions from true premises or not; and an inference is regarded as valid or not, without reference to the truth or falsity of its conclusion specially, but according as the habit which determines it is such as to produce true conclusions in general or not. The particular habit of mind which governs this or that inference may be formulated in a proposition whose truth depends on the validity of the inferences which the habit determines; and such a formula is called a *guiding principle* of inference. Suppose, for example, that we observe that a rotating disk of copper quickly comes to rest when placed between the poles of a magnet, and we infer that this will happen with every disk of copper. The guiding principle is, that what is true of one piece of copper is true of another. Such a guiding principle with regard to copper would be much safer than with regard to many other substances—brass, for example.

A book might be written to signalize all the most important of these guiding principles of reasoning. It would probably be, we must confess, of no service to a person whose thought is directed wholly to practical subjects, and whose activity moves along thoroughly-beaten paths. The problems which present themselves to such a mind are matters of routine which he has learned once for all to handle in learning his business. But let a man venture into an unfamiliar field, or where his results are not continually checked by experience, and all history shows that the most masculine intellect will ofttimes lose his orientation and waste his efforts in directions which bring him no nearer to his goal, or even carry him entirely astray. He is like a ship in the open sea, with no one on board who understands the rules of navigation. And in such a case some general study of the guiding principles of reasoning would be sure to be found useful.

The subject could hardly be treated, however, without being first limited; since almost any fact may serve as a guiding principle. But it so happens that there exists a division among facts, such that in one class are all those which are absolutely essential as guiding principles, while in the others are all which have any other interest as objects of research. This division is between those which are necessarily taken for granted in asking whether a certain conclusion follows from certain premises, and those which are not implied in that question. A moment's thought will show that a variety of facts are already assumed when the logical question is first asked. It is implied, for instance, that there are such states of mind as doubt and belief—that a passage from one to the other is possible, the object of thought remaining the same, and that this transition is subject to some rules which all minds are alike bound by. As these are facts

which we must already know before we can have any clear conception of reasoning at all, it cannot be supposed to be any longer of much interest to inquire into their truth or falsity. On the other hand, it is easy to believe that those rules of reasoning which are deduced from the very idea of the process are the ones which are the most essential; and, indeed, that so long as it conforms to these it will, at least, not lead to false conclusions from true premises. In point of fact, the importance of what may be deduced from the assumptions involved in the logical question turns out to be greater than might be supposed, and this for reasons which it is difficult to exhibit at the outset. The only one which I shall here mention is, that conceptions which are really products of logical reflection, without being readily seen to be so, mingle with our ordinary thoughts, and are frequently the causes of great confusion. This is the case, for example, with the conception of quality. A quality as such is never an object of observation. We can see that a thing is blue or green, but the quality of being blue and the quality of being green are not things which we see; they are products of logical reflection. The truth is, that common-sense, or thought as it first emerges above the level of the narrowly practical, is deeply imbued with that bad logical quality to which the epithet *metaphysical* is commonly applied; and nothing can clear it up but a severe course of logic.

III.

We generally know when we wish to ask a question and when we wish to pronounce a judgment, for there is a dissimilarity between the sensation of doubting and that of believing.

But this is not all which distinguishes doubt from belief. There is a practical difference. Our beliefs guide our desires and shape our actions. The Assassins, or followers of the Old Man of the Mountain, used to rush into death at his least command, because they believed that obedience to him would insure everlasting felicity. Had they doubted this, they would not have acted as they did. So it is with every belief, according to its degree. The feeling of believing is a more or less sure indication of there being established in our nature some habit which will determine our actions. Doubt never has such an effect.

Nor must we overlook a third point of difference. Doubt is an uneasy and dissatisfied state from which we struggle to free ourselves and pass into the state of belief; while the latter is a calm and satisfactory state which we do not wish to avoid, or to change to a belief in anything else.[1] On the contrary, we cling tenaciously, not merely to believing, but to believing just what we do believe.

[1] I am not speaking of secondary effects occasionally produced by the interference of other impulses.

Thus, both doubt and belief have positive effects upon us, though very different ones. Belief does not make us act at once, but puts us into such a condition that we shall behave in a certain way, when the occasion arises. Doubt has not the least effect of this sort, but stimulates us to action until it is destroyed. This reminds us of the irritation of a nerve and the reflex action produced thereby; while for the analogue of belief, in the nervous system, we must look to what are called nervous associations—for example, to that habit of the nerves in consequence of which the smell of a peach will make the mouth water.

IV.

The irritation of doubt causes a struggle to attain a state of belief. I shall term this struggle *inquiry*, though it must be admitted that this is sometimes not a very apt designation.

The irritation of doubt is the only immediate motive for the struggle to attain belief. It is certainly best for us that our beliefs should be such as may truly guide our actions so as to satisfy our desires; and this reflection will make us reject any belief which does not seem to have been so formed as to insure this result. But it will only do so by creating a doubt in the place of that belief. With the doubt, therefore, the struggle begins, and with the cessation of doubt it ends. Hence, the sole object of inquiry is the settlement of opinion. We may fancy that this is not enough for us, and that we seek, not merely an opinion, but a true opinion. But put this fancy to the test, and it proves groundless; for as soon as a firm belief is reached we are entirely satisfied, whether the belief be true or false. And it is clear that nothing out of the sphere of our knowledge can be our object, for nothing which does not affect the mind can be the motive for a mental effort. The most that can be maintained is, that we seek for a belief that we shall *think* to be true. But we think each one of our beliefs to be true, and, indeed, it is mere tautology to say so.

That the settlement of opinion is the sole end of inquiry is a very important proposition. It sweeps away, at once, various vague and erroneous conceptions of proof. A few of these may be noticed here.

1. Some philosophers have imagined that to start an inquiry it was only necessary to utter a question or set it down upon paper, and have even recommended us to begin our studies with questioning everything! But the mere putting of a proposition into the interrogative form does not stimulate the mind to any struggle after belief. There must be a real and living doubt, and without this all discussion is idle.

2. It is a very common idea that a demonstration must rest on some ultimate and absolutely indubitable propositions. These, according to one school, are first principles of a general nature; according to another, are first sensations. But, in point of fact, an inquiry,

to have that completely satisfactory result called demonstration, has only to start with propositions perfectly free from all actual doubt. If the premises are not in fact doubted at all, they cannot be more satisfactory than they are.

3. Some people seem to love to argue a point after all the world is fully convinced of it. But no further advance can be made. When doubt ceases, mental action on the subject comes to an end; and, if it did go on, it would be without a purpose.

V.

If the settlement of opinion is the sole object of inquiry, and if belief is of the nature of a habit, why should we not attain the desired end, by taking any answer to a question which we may fancy, and constantly reiterating it to ourselves, dwelling on all which may conduce to that belief, and learning to turn with contempt and hatred from anything which might disturb it? This simple and direct method is really pursued by many men. I remember once being entreated not to read a certain newspaper lest it might change my opinion upon free-trade. "Lest I might be entrapped by its fallacies and misstatements," was the form of expression. "You are not," my friend said, "a special student of political economy. You might, therefore, easily be deceived by fallacious arguments upon the subject. You might, then, if you read this paper, be led to believe in protection. But you admit that free-trade is the true doctrine; and you do not wish to believe what is not true." I have often known this system to be deliberately adopted. Still oftener, the instinctive dislike of an undecided state of mind, exaggerated into a vague dread of doubt, makes men cling spasmodically to the views they already take. The man feels that, if he only holds to his belief without wavering, it will be entirely satisfactory. Nor can it be denied that a steady and immovable faith yields great peace of mind. It may, indeed, give rise to inconveniences, as if a man should resolutely continue to believe that fire would not burn him, or that he would be eternally damned if he received his *ingesta* otherwise than through a stomach-pump. But then the man who adopts this method will not allow that its inconveniences are greater than its advantages. He will say, "I hold steadfastly to the truth, and the truth is always wholesome." And in many cases it may very well be that the pleasure he derives from his calm faith overbalances any inconveniences resulting from its deceptive character. Thus, if it be true that death is annihilation, then the man who believes that he will certainly go straight to heaven when he dies, provided he have fulfilled certain simple observances in this life, has a cheap pleasure which will not be followed by the least disappointment. A similar consideration seems to have weight with many persons in religious topics, for we frequently hear it said, "Oh,

I could not believe so-and-so, because I should be wretched if I did." When an ostrich buries its head in the sand as danger approaches, it very likely takes the happiest course. It hides the danger, and then calmly says there is no danger; and, if it feels perfectly sure there is none, why should it raise its head to see? A man may go through life, systematically keeping out of view all that might cause a change in his opinions, and if he only succeeds—basing his method, as he does, on two fundamental psychological laws—I do not see what can be said against his doing so. It would be an egotistical impertinence to object that his procedure is irrational, for that only amounts to saying that his method of settling belief is not ours. He does not propose to himself to be rational, and, indeed, will often talk with scorn of man's weak and illusive reason. So let him think as he pleases.

But this method of fixing belief, which may be called the method of tenacity, will be unable to hold its ground in practice. The social impulse is against it. The man who adopts it will find that other men think differently from him, and it will be apt to occur to him, in some saner moment, that their opinions are quite as good as his own, and this will shake his confidence in his belief. This conception, that another man's thought or sentiment may be equivalent to one's own, is a distinctly new step, and a highly important one. It arises from an impulse too strong in man to be suppressed, without danger of destroying the human species. Unless we make ourselves hermits, we shall necessarily influence each other's opinions; so that the problem becomes how to fix belief, not in the individual merely, but in the community.

Let the will of the state act, then, instead of that of the individual. Let an institution be created which shall have for its object to keep correct doctrines before the attention of the people, to reiterate them perpetually, and to teach them to the young; having at the same time power to prevent contrary doctrines from being taught, advocated, or expressed. Let all possible causes of a change of mind be removed from men's apprehensions. Let them be kept ignorant, lest they should learn of some reason to think otherwise than they do. Let their passions be enlisted, so that they may regard private and unusual opinions with hatred and horror. Then, let all men who reject the established belief be terrified into silence. Let the people turn out and tar-and-feather such men, or let inquisitions be made into the manner of thinking of suspected persons, and, when they are found guilty of forbidden beliefs, let them be subjected to some signal punishment. When complete agreement could not otherwise be reached, a general massacre of all who have not thought in a certain way has proved a very effective means of settling opinion in a country. If the power to do this be wanting, let a list of opinions be drawn up, to which no man of the least independence of thought can

assent, and let the faithful be required to accept all these propositions, in order to segregate them as radically as possible from the influence of the rest of the world.

This method has, from the earliest times, been one of the chief means of upholding correct theological and political doctrines, and of preserving their universal or catholic character. In Rome, especially, it has been practised from the days of Numa Pompilius to those of Pius Nonus. This is the most perfect example in history; but wherever there is a priesthood—and no religion has been without one—this method has been more or less made use of. Wherever there is an aristocracy, or a guild, or any association of a class of men whose interests depend or are supposed to depend on certain propositions, there will be inevitably found some traces of this natural product of social feeling. Cruelties always accompany this system; and when it is consistently carried out, they become atrocities of the most horrible kind in the eyes of any rational man. Nor should this occasion surprise, for the officer of a society does not feel justified in surrendering the interests of that society for the sake of mercy, as he might his own private interests. It is natural, therefore, that sympathy and fellowship should thus produce a most ruthless power.

In judging this method of fixing belief, which may be called the method of authority, we must, in the first place, allow its immeasurable mental and moral superiority to the method of tenacity. Its success is proportionately greater; and, in fact, it has over and over again worked the most majestic results. The mere structures of stone which it has caused to be put together—in Siam, for example, in Egypt, and in Europe—have many of them a sublimity hardly more than rivaled by the greatest works of Nature. And, except the geological epochs, there are no periods of time so vast as those which are measured by some of these organized faiths. If we scrutinize the matter closely, we shall find that there has not been one of their creeds which has remained always the same; yet the change is so slow as to be imperceptible during one person's life, so that individual belief remains sensibly fixed. For the mass of mankind, then, there is perhaps no better method than this. If it is their highest impulse to be intellectual slaves, then slaves they ought to remain.

But no institution can undertake to regulate opinions upon every subject. Only the most important ones can be attended to, and on the rest men's minds must be left to the action of natural causes. This imperfection will be no source of weakness so long as men are in such a state of culture that one opinion does not influence another—that is, so long as they cannot put two and two together. But in the most priestridden states some individuals will be found who are raised above that condition. These men possess a wider sort of social

feeling; they see that men in other countries and in other ages have held to very different doctrines from those which they themselves have been brought up to believe; and they cannot help seeing that it is the mere accident of their having been taught as they have, and of their having been surrounded with the manners and associations they have, that has caused them to believe as they do and not far differently. And their candor cannot resist the reflection that there is no reason to rate their own views at a higher value than those of other nations and other centuries; and this gives rise to doubts in their minds.

They will further perceive that such doubts as these must exist in their minds with reference to every belief which seems to be determined by the caprice either of themselves or of those who originated the popular opinions. The willful adherence to a belief, and the arbitrary forcing of it upon others, must, therefore, both be given up, and a new method of settling opinions must be adopted, which shall not only produce an impulse to believe, but shall also decide what proposition it is which is to be believed. Let the action of natural preferences be unimpeded, then, and under their influence let men, conversing together and regarding matters in different lights, gradually develop beliefs in harmony with natural causes. This method resembles that by which conceptions of art have been brought to maturity. The most perfect example of it is to be found in the history of metaphysical philosophy. Systems of this sort have not usually rested upon any observed facts, at least not in any great degree. They have been chiefly adopted because their fundamental propositions seemed "agreeable to reason." This is an apt expression; it does not mean that which agrees with experience, but that which we find ourselves inclined to believe. Plato, for example, finds it agreeable to reason that the distances of the celestial spheres from one another should be proportional to the different lengths of strings which produce harmonious chords. Many philosophers have been led to their main conclusions by considerations like this; but this is the lowest and least developed form which the method takes, for it is clear that another man might find Kepler's theory, that the celestial spheres are proportional to the inscribed and circumscribed spheres of the different regular solids, more agreeable to *his* reason. But the shock of opinions will soon lead men to rest on preferences of a far more universal nature. Take, for example, the doctrine that man only acts selfishly—that is, from the consideration that acting in one way will afford him more pleasure than acting in another. This rests on no fact in the world, but it has had a wide acceptance as being the only reasonable theory.

This method is far more intellectual and respectable from the point of view of reason than either of the others which we have noticed. But its failure has been the most manifest. It makes of inquiry

something similar to the development of taste; but taste, unfortunately, is always more or less a matter of fashion, and accordingly metaphysicians have never come to any fixed agreement, but the pendulum has swung backward and forward between a more material and a more spiritual philosophy, from the earliest times to the latest. And so from this, which has been called the *a priori* method, we are driven, in Lord Bacon's phrase, to a true induction. We have examined into this *a priori* method as something which promised to deliver our opinions from their accidental and capricious element. But development, while it is a process which eliminates the effect of some casual circumstances, only magnifies that of others. This method, therefore, does not differ in a very essential way from that of authority. The government may not have lifted its finger to influence my convictions; I may have been left outwardly quite free to choose, we will say, between monogamy and polygamy, and, appealing to my conscience only, I may have concluded that the latter practice is in itself licentious. But when I come to see that the chief obstacle to the spread of Christianity among a people of as high culture as the Hindoos has been a conviction of the immorality of our way of treating women, I cannot help seeing that, though governments do not interfere, sentiments in their development will be very greatly determined by accidental causes. Now, there are some people, among whom I must suppose that my reader is to be found, who, when they see that any belief of theirs is determined by any circumstance extraneous to the facts, will from that moment not merely admit in words that that belief is doubtful, but will experience a real doubt of it, so that it ceases to be a belief.

To satisfy our doubts, therefore, it is necessary that a method should be found by which our beliefs may be caused by nothing human, but by some external permanency—by something upon which our thinking has no effect. Some mystics imagine that they have such a method in a private inspiration from on high. But that is only a form of the method of tenacity, in which the conception of truth as something public is not yet developed. Our external permanency would not be external, in our sense, if it was restricted in its influence to one individual. It must be something which affects, or might affect, every man. And, though these affections are necessarily as various as are individual conditions, yet the method must be such that the ultimate conclusion of every man shall be the same. Such is the method of science. Its fundamental hypothesis, restated in more familiar language, is this: There are real things, whose characters are entirely independent of our opinions about them; those realities affect our senses according to regular laws, and, though our sensations are as different as our relations to the objects, yet, by taking advantage of the laws of perception, we can ascertain by reasoning how things really are, and any man, if he have sufficient experience

and reason enough about it, will be led to the one true conclusion. The new conception here involved is that of reality. It may be asked how I know that there are any realities. If this hypothesis is the sole support of my method of inquiry, my method of inquiry must not be used to support my hypothesis. The reply is this: 1. If investigation cannot be regarded as proving that there are real things, it at least does not lead to a contrary conclusion; but the method and the conception on which it is based remain ever in harmony. No doubts of the method, therefore, necessarily arise from its practice, as is the case with all the others. 2. The feeling which gives rise to any method of fixing belief is a dissatisfaction at two repugnant propositions. But here already is a vague concession that there is some *one* thing to which a proposition should conform. Nobody, therefore, can really doubt that there are realities, or, if he did, doubt would not be a source of dissatisfaction. The hypothesis, therefore, is one which every mind admits. So that the social impulse does not cause me to doubt it. 3. Everybody uses the scientific method about a great many things, and only ceases to use it when he does not know how to apply it. 4. Experience of the method has not led me to doubt it, but, on the contrary, scientific investigation has had the most wonderful triumphs in the way of settling opinion. These afford the explanation of my not doubting the method or the hypothesis which it supposes; and not having any doubt, nor believing that anybody else whom I could influence has, it would be the merest babble for me to say more about it. If there be anybody with a living doubt upon the subject, let him consider it.

To describe the method of scientific investigation is the object of this series of papers. At present I have only room to notice some points of contrast between it and other methods of fixing belief.

This is the only one of the four methods which presents any distinction of a right and a wrong way. If I adopt the method of tenacity and shut myself out from all influences, whatever I think necessary to doing this is necessary according to that method. So with the method of authority: the state may try to put down heresy by means which, from a scientific point of view, seem very ill-calculated to accomplish its purposes; but the only test *on that method* is what the state thinks, so that it cannot pursue the method wrongly. So with the *a priori* method. The very essence of it is to think as one is inclined to think. All metaphysicians will be sure to do that, however they may be inclined to judge each other to be perversely wrong. The Hegelian system recognizes every natural tendency of thought as logical, although it be certain to be abolished by counter-tendencies. Hegel thinks there is a regular system in the succession of these tendencies, in consequence of which, after drifting one way and the other for a long time, opinion will at last go right.

And it is true that metaphysicians get the right ideas at last; Hegel's system of Nature represents tolerably the science of that day; and one may be sure that whatever scientific investigation has put out of doubt will presently receive *a priori* demonstration on the part of the metaphysicians. But with the scientific method the case is different. I may start with known and observed facts to proceed to the unknown; and yet the rules which I follow in doing so may not be such as investigation would approve. The test of whether I am truly following the method is not an immediate appeal to my feelings and purposes, but, on the contrary, itself involves the application of the method. Hence it is that bad reasoning as well as good reasoning is possible; and this fact is the foundation of the practical side of logic.

It is not to be supposed that the first three methods of settling opinion present no advantage whatever over the scientific method. On the contrary, each has some peculiar convenience of its own. The *a priori* method is distinguished for its comfortable conclusions. It is the nature of the process to adopt whatever belief we are inclined to, and there are certain flatteries to the vanity of man which we all believe by nature, until we are awakened from our pleasing dream by some rough facts. The method of authority will always govern the mass of mankind; and those who wield the various forms of organized force in the state will never be convinced that dangerous reasoning ought not to be suppressed in some way. If liberty of speech is to be untrammeled from the grosser forms of constraint, then uniformity of opinion will be secured by a moral terrorism to which the respectability of society will give its thorough approval. Following the method of authority is the path of peace. Certain non-conformities are permitted; certain others (considered unsafe) are forbidden. These are different in different countries and in different ages; but, wherever you are, let it be known that you seriously hold a tabooed belief, and you may be perfectly sure of being treated with a cruelty less brutal but more refined than hunting you like a wolf. Thus, the greatest intellectual benefactors of mankind have never dared, and dare not now, to utter the whole of their thought; and thus a shade of *prima facie* doubt is cast upon every proposition which is considered essential to the security of society. Singularly enough, the persecution does not all come from without; but a man torments himself and is oftentimes most distressed at finding himself believing propositions which he has been brought up to regard with aversion. The peaceful and sympathetic man will, therefore, find it hard to resist the temptation to submit his opinions to authority. But most of all I admire the method of tenacity for its strength, simplicity, and directness. Men who pursue it are distinguished for their decision of character, which becomes very easy with such a mental rule. They do not waste time in trying to make up their minds what they want,

but, fastening like lightning upon whatever alternative comes first, they hold to it to the end, whatever happens, without an instant's irresolution. This is one of the splendid qualities which generally accompany brilliant, unlasting success. It is impossible not to envy the man who can dismiss reason, although we know how it must turn out at last.

Such are the advantages which the other methods of settling opinion have over scientific investigation. A man should consider well of them; and then he should consider that, after all, he wishes his opinions to coincide with the fact, and that there is no reason why the results of these three methods should do so. To bring about this effect is the prerogative of the method of science. Upon such considerations he has to make his choice—a choice which is far more than the adoption of any intellectual opinion, which is one of the ruling decisions of his life, to which, when once made, he is bound to adhere. The force of habit will sometimes cause a man to hold on to old beliefs, after he is in a condition to see that they have no sound basis. But reflection upon the state of the case will overcome these habits, and he ought to allow reflection its full weight. People sometimes shrink from doing this, having an idea that beliefs are wholesome which they cannot help feeling rest on nothing. But let such persons suppose an analogous though different case from their own. Let them ask themselves what they would say to a reformed Mussulman who should hesitate to give up his old notions in regard to the relations of the sexes; or to a reformed Catholic who should still shrink from reading the Bible. Would they not say that these persons ought to consider the matter fully, and clearly understand the new doctrine, and then ought to embrace it, in its entirety? But, above all, let it be considered that what is more wholesome than any particular belief is integrity of belief, and that to avoid looking into the support of any belief from a fear that it may turn out rotten is quite as immoral as it is disadvantageous. The person who confesses that there is such a thing as truth, which is distinguished from falsehood simply by this, that if acted on it will carry us to the point we aim at and not astray, and then, though convinced of this, dares not know the truth and seeks to avoid it, is in a sorry state of mind indeed.

Yes, the other methods do have their merits: a clear logical conscience does cost something—just as any virtue, just as all that we cherish, costs us dear. But we should not desire it to be otherwise. The genius of a man's logical method should be loved and reverenced as his bride, whom he has chosen from all the world. He need not contemn the others; on the contrary, he may honor them deeply, and in doing so he only honors her the more. But she is the one that he has chosen, and he knows that he was right in making that choice. And having made it, he will work and fight for her, and will not com-

plain that there are blows to take, hoping that there may be as many and as hard to give, and will strive to be the worthy knight and champion of her from the blaze of whose splendors he draws his inspiration and his courage.

THE GROWTH OF THE STEAM-ENGINE.[1]

By Professor R. H. THURSTON,
of the Stevens Institute of Technology.

Fig. 1.—The Grecian Idea of the Steam-Engine.

[1] This sketch is condensed from lectures originally written for delivery to an audience of engineers and mechanics, at the Stevens Institute of Technology, in the winter of 1871–'72, and from lectures since prepared for classes in the Department of Mechanical Engineering, and revised to date. The most novel portion—referring to the practical realization of the "perfect steam-engine"— is here more fully developed than it had previously been, and the paper, as a whole, is for the first time here published. The illustrations are principally from Stuart and Farey, and from the article "Steam-Engine," prepared by the writer of these lectures for Appletons' Cyclopædia, new edition.

A very complete history of "The Growth of the Steam-Engine" has been prepared by

I.

THE STEAM-ENGINE AS A SIMPLE MACHINE.

["A machine, receiving at distant times and from many hands new combinations and improvements, and becoming at last of signal benefit to mankind, may be compared to a rivulet, swelled in its course by tributary streams until it rolls along a majestic river, enriching in its progress provinces and kingdoms. In retracing the current, too, from where it mingles with the ocean, the pretensions of even ample subsidiary streams are merged in our admiration of the master-flood. But, as we continue to ascend, those waters which, nearer the sea, would have been disregarded as unimportant, begin to rival in magnitude, and divide our attention with, the parent stream; until, at length, on our approaching the fountains of the river, it appears trickling from the rock, or oozing from among the flowers of the valley. So, also, in developing the rise of a machine, a coarse instrument or a toy may be recognized as the germ of that production of mechanical genius whose power and usefulness have stimulated our curiosity to mark its changes and to trace its origin. The same feelings of reverential gratitude which attached holiness to the spots whence mighty rivers sprung, also clothed with divinity, and raised altars in honor of the saw, the plough, the potter's wheel, and the loom."—STUART.]

[. . . . "And, last of all, with inimitable power, and 'with whirlwind-sound,' comes the potent agency of steam. In comparison with the past, what centuries of improvement has this single agent comprised in the short compass of fifty years! Everywhere practicable, everywhere efficient, it has an arm a thousand times stronger than that of Hercules, and to which human ingenuity is capable of fitting a thousand times as many hands as belonged to Briareus. Steam is found in triumphant operation on the seas; and, under the influence of its strong propulsion, the gallant ship—

'Against the wind, against the tide,
Still steadies with an upright keel.'

It is on the rivers, and the boatman may repose on his oars; it is on highways, and exerts itself along the courses of land-conveyance; it is at the bottom of mines, a thousand feet below the earth's surface; it is in the mill, and in the workshops of the trades. It rows, it pumps, it excavates, it carries, it draws, it lifts, it hammers, it spins, it weaves, it prints. It seems to say to men, at least to the class of artisans: 'Leave off your manual labor; give over your bodily toil; bestow but your skill and reason to the directing of my power, and I will bear the toil, with no muscle to grow weary, no nerve to relax, no breast to feel faintness!' What further improvement may still be made in the use of this astonishing power it is impossible to know, and it were vain to conjecture. What we do know is, that it has most essentially altered the face of affairs, and that no visible limit yet appears beyond which its progress is seen to be impossible."—DANIEL WEBSTER.]

SECTION I. *The Period of Speculation.* HERO TO WORCESTER. B. C. 200 to A. D. 1700.—1. The history of the steam-engine is a subject that interests greatly every intelligent mind.

As Religion has always been, and still is, the great *moral* agent in

the same author, and is about to be published, finely illustrated, in the "International Series."

civilizing the world, and as Science is the great *intellectual* promoter of civilization, so the steam-engine is, in modern times, the most important physical agent in that great work.

It would be superfluous to attempt to enumerate the benefits which it has conferred upon the human race, for such an enumeration would include an addition to every comfort, and the creation of almost every luxury that we now enjoy.

"It has increased the sum of human happiness, not only by calling new pleasures into existence, but by so cheapening former enjoyments as to render them attainable by those who before could never have hoped to share them."[1]

2. The wonderful progress of the present century is, in a very great degree, due to the invention and improvement of the steam-engine, and to the ingenious application of its power to kinds of work that formerly tasked the physical energies of the human race. We cannot examine the methods and processes of any branch of industry without discovering somewhere the assistance and support of this wonderful machine.

Relieving mankind from manual toil, it has left to the intellect the privilege of directing the power formerly absorbed in physical labor into other and more profitable channels. The intelligence which has thus conquered the powers of Nature now finds itself free to do brain-work; the force formerly utilized in the carrying of water and the hewing of wood is now expended in the Godlike work of *thought*.

What, then, can be more interesting than to trace the history of the growth of this wonderful invention, the greatest among the many great creations of one of God's most beneficent gifts to man, the power of invention.

3. While following the records and traditions of the steam-engine, I propose to call to your attention the fact that its history illustrates the very important truth that great inventions are never, and great discoveries are seldom, the work of any one mind.

Every great invention is really an aggregation of minor inventions, or the final step of a progression. It is not usually a creation, but a growth, as truly so as is the growth of the trees in the forest.

Hence the same invention is frequently brought out in several countries and by several individuals simultaneously.

Frequently, an important invention is made before the world is ready to receive it, and the unhappy inventor is taught, by his failure, that it is as unfortunate to be in advance of the age as to be behind it.

Inventions only become successful when they are not only needed, but when mankind is so far advanced in intelligence as to appreciate and to express the necessity for them, and at once to make use of them.

4. About a half-century ago, an able New England writer, in a

[1] Dr. Lardner.

communication to an English engineering periodical, described the new machinery which was built at Newport, Rhode Island, by John Babcock and Robert L. Thurston, for one of the first steamboats that ever ran between that city and New York. He prefaced his description with a frequently-quoted remark to the effect that, as Minerva sprang, mature in mind, in full stature of body, and completely armed, from the head of Jupiter, so the steam-engine came forth, perfect at its birth, from the brain of James Watt.

But we shall see, as we examine the records of its history, that, although James Watt was *an* inventor, and probably the greatest of the inventors of the steam-engine, he was still but one of the many men who have aided in perfecting it, and who have now made us so familiar with its tremendous power and its facile adaptation to labor, that we have almost ceased to admire it, or to wonder at this product of the workings of the more admirable intelligence that has so far perfected it.

5. Twenty-one centuries ago, the political power of Greece was broken, although Grecian civilization had risen to its zenith.

Rome, ruder than her polished neighbor, was growing continually stronger, and was rapidly gaining territory by absorbing weaker states.

Egypt, older in civilization than either Greece or Rome, fell but two centuries later before the assault of the younger states, and became a Roman province. Her principal city was at this time Alexandria, founded by the great soldier whose name it bears when in the full tide of his prosperity. It had now become a great and prosperous city, the centre of the commerce of the world, the home of students and of learned men, and its population was the wealthiest and most civilized of the then known world.

It is among the relics of this ancient Egyptian civilization that we find the first record of the early history of the steam-engine.

6. In Alexandria, the home of Euclid, the great geometrician, and possibly contemporary with that talented engineer and mathematician Archimedes, a learned writer, Hero, produced a manuscript which he entitled "Spiritalia seu Pneumatica."

The work is still extant, and has been several times republished. In it are described a number of interesting though primitive forms of water and heat engines, and, among the latter, that shown in Fig. 2,[1] an apparatus moved by the force of steam.

This earliest of steam-engines consisted of a globe, *a*, suspended between trunnions, *G L*, through one of which steam enters through pipes, *C M*, *F E*, from the boiler, *D*, below.

The hollow bent arms, *H* and *K*, cause the vapor to issue in such a direction that the reaction produces a rotary movement of the globe, just as the rotation of reaction water-wheels is produced by outflowing water.

[1] *Vide* Woodcroft's "Translation of Hero."

It is quite uncertain whether this machine was ever more than a toy, although it has been supposed by some authorities that it was actually used by the Greek priests for the purpose of producing motion of other apparatus in their temples.

FIG. 2.—HERO'S ENGINE, B. C. 200.

7. It seems sufficiently remarkable that, while the power of steam had been, during all the many centuries that man has existed upon the globe, so universally displayed in so many of the phenomena of natural change, mankind lived almost up to the Christian era without making it useful in giving motion even to a toy; but it must excite still greater surprise that, from the time of Hero, we meet with no good evidence of its application to any practical use for many hundreds of years.

Here and there, in the pages of history and in special treatises, we find a hint that the knowledge of the force of steam is not forgotten; but it is not at all to the credit of biographers and of historians that they have devoted so little time to the task of seeking and recording information relating to the progress of this and other important inventions and improvements in the mechanic arts.

8. In the year 1825, the Superintendent of the Royal Spanish Archives at Simancas furnished an account, which had been there discovered, of an attempt made in 1543, by Blasco de Garay, a Spanish navy-officer, under Charles I.,[1] to move a ship by paddle-wheels, driven, as was inferred from the account, by a steam-engine.

It is impossible to say to how much confidence the story is entitled; but, if true, it was the first attempt, so far as is now known, to make steam useful in developing power for practical purposes. Nothing is known of the form of the engine employed, it only having been stated that a "vessel of boiling water" formed a part of it.

The account is, however, in other respects, so circumstantial that it has been credited by many, but it is looked upon as very doubtful by the majority of writers upon the subject. It was published in 1825

[1] Charles V., Emperor of Germany, was also Charles I. of Spain.

by M. de Navarrete, in the form of a letter from Tomás Gonzales, Director of the Royal Archives at Simancas, Spain.

9. In 1601 Giovanni Battista della Porta, in his work "Spiritali," described an apparatus by which the pressure of steam might be made to raise a column of water, and the method of operation included the application of the condensation of steam to the production of a vacuum into which the water would flow. He used a separate boiler. Fig. 3 is copied from an illustration in a later edition of his work.[1]

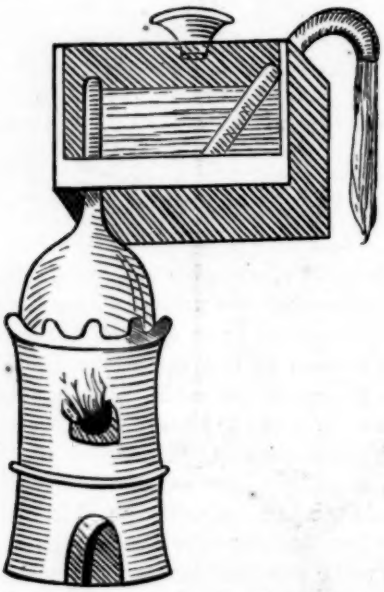


FIG. 3.—PORTA'S APPARATUS, A. D. 1601.

10. In 1615 Salmon de Caus, who had been an engineer and architect under Louis XIII. of France, and later in the employ of the British Prince of Wales, published a work at Frankfort, entitled "Les Raisons des Forces Mouvantes avec diverses machines tant utile que plaisantes," in which he illustrated his proposition, "Water will, by the aid of fire, mount higher than its level," by describing a machine designed to raise water by the expanding power of steam. (*See* Fig. 4.)

This consisted of a metal vessel partly filled with water, and in which a pipe was fitted leading nearly to the bottom and open at the top.

Fire being applied, the steam, formed by its elastic force, drove the water out through the vertical pipe, raising it to a height depending upon either the wish of the builder or the strength of the vessel.

11. In 1629 Giovanni Branca, of Lovetto, an Italian town, de-

[1] "I Tre Libri Spiritali," Napoli, 1606.

scribed, in a work published at Rome, a number of ingenious mechanical contrivances, among which was a steam-engine (Fig. 5), in which the steam, issuing from a boiler, impinged upon the vanes of an horizontal wheel.

This it was proposed to apply to many useful purposes.

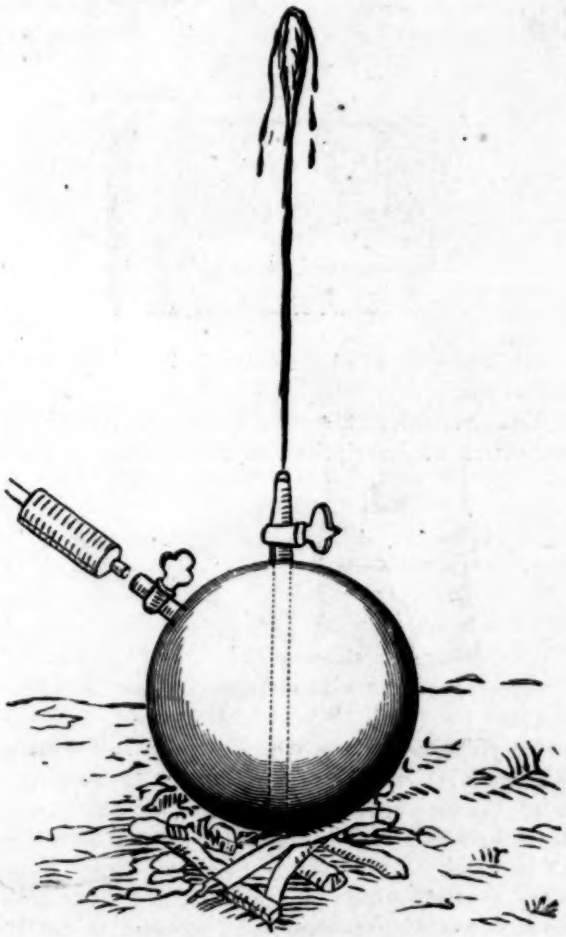


FIG. 4.—DE CAUS'S APPARATUS, A. D. 1615.

12. In illustration of the singular manner in which old inventions disappear only to reappear in latter times, it may be remarked that this contrivance was brought forward quite recently by a sanguine inventor, who spent a considerable sum in building what he considered a great improvement upon existing forms of steam-engines.

The engine of Hero also has been frequently reinvented, and, un-

der the designation of "steam turbine," it has been applied with some satisfactory effect to the production of very high velocity of rotation.

13. We now come to the first instance in which the expansive

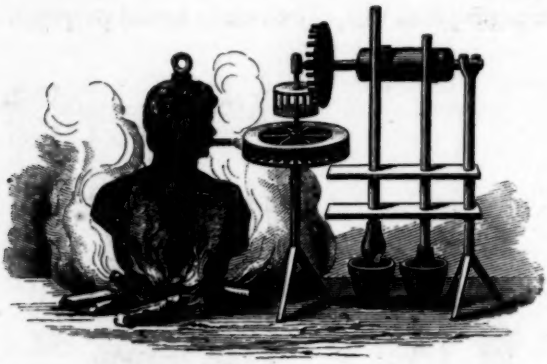


FIG. 5.—BRANCA'S STEAM-ENGINE, A. D. 1629.

force of steam is supposed to have actually been applied to do important and useful work.

In 1663, Edward Somerset, second Marquis of Worcester, published a curious collection of descriptions of his inventions, couched in ob-

EDWARD SOMERSET, SECOND MARQUIS OF WORCESTER.

scure and singular language, and called a "Century of the Names and Scantlings of Inventions by me already practised."

One of these inventions is an apparatus for raising water by steam.

The description was not accompanied by a drawing, but the sketch here given (Fig. 6), probably resembles his contrivance very closely.

Steam is generated in the boiler *D*, and thence is led into the vessel *A*, already nearly filled with water. It drives the water in a jet out through a pipe, *F* or *F'*. The vessel *A* is then shut off from the

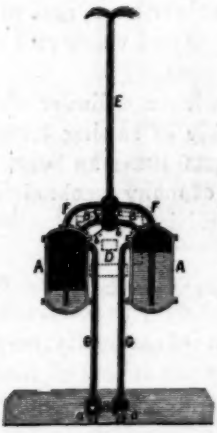


FIG. 6.—WORCESTER'S ENGINE, A. D. 1650.

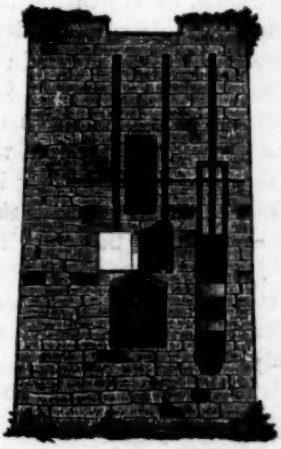


FIG. 7.—WALL OF RAGLAN CASTLE.

boiler and again filled "by suction" after the steam has condensed through the pipe *G*, and the operation is repeated, the vessel *B* being used alternately with *A*.

The instruments of Porta and of De Caus were "steam fountains," and were applied, if used at all, merely for ornamental uses.

That of the Marquis of Worcester was used for the purpose of elevating water for practical purposes at Vauxhall, near London. It was still earlier used at the home of Worcester, Raglan Castle, where the openings cut in the wall for its reception are still to be seen, as in Fig. 7.

14. The *separate boiler*, as here used, constitutes a very important improvement upon the preceding forms of apparatus, although the idea was original with Porta.

The "water-commanding engine," as its inventor called it, was, therefore, the first instance in the history of the steam-engine in which the inventor is known to have "reduced his invention to practice."

It is evident, however, that the invention, important as it was, does not entitle the marquis to the honor claimed for him by many authorities of being *the inventor* of the steam-engine. Somerset was simply *one* of those whose works collectively make the steam-engine.

SECTION II. *The Period of Application of the Early Type of Steam-Engine. Morland, Savery, and Desaguliers.*—14. The inven-

tion of the Marquis of Worcester was revived twenty years later, by Sir Samuel Morland, but in what form is not now known.

In a memoir,[1] which he wrote upon the subject in 1683, he exhibited a degree of familiarity with the properties of steam that could hardly have been expected of any one at that early date.

In his manuscript, now preserved in the Haarlem Collection of the British Museum, he states the size of the cylinders required in his machine to raise given quantities of water per hour, and gives very exactly the relative volumes of equal weights of water and of steam under atmospheric pressure.

He tells us that one of his engines, with a cylinder six feet in diameter and twelve feet long, was capable of raising 3,240 pounds of water through a height of six inches, 1,800 times an hour.

15. From this time forward the minds of many mechanicians were earnestly at work on this problem—the raising of water by aid of steam.

Hitherto, although many ingenious toys, embodying the principles of the steam-engine separately, and sometimes, to a certain extent, collectively, had been proposed and even occasionally constructed, the world was only just ready to profit by the labors of inventors in this direction.

But, at the end of the seventeenth century, English miners were beginning to find the greatest difficulty in clearing their shafts of the vast quantities of water which they were meeting at the considerable depths to which they had penetrated, and it had become a matter of vital importance to them to find a more powerful aid in that work than was then available.

They were, therefore, by their necessities, stimulated to watch for, and to be prepared promptly to take advantage of, such an invention when it should be offered them.

16. The experiments of Papin, and the practical application of known principles by Savery, placed the needed apparatus in their hands.

When Louis XIV. revoked the Edict of Nantes, by which Henry IV. had guaranteed protection to the Protestants of France, the terrible persecutions at once commenced by the papists drove from the kingdom some of its greatest men.

Among these was Denys Papin, a native of Blois, and a distinguished philosopher. He studied medicine at Paris, and, when expatriated, went to England, where he met the celebrated philosopher Boyle, who introduced him into the Royal Society, of which Papin became a member, and to whose "Transactions" he contributed several valuable papers.

He invented, in 1680, the "Digester," in which substances, unaf-

[1] "Élévation des Eaux, par toutes Sortes de Machine, reduite à la Mesure, au Poids et à la Balance."

fected by water boiling under atmospheric pressure, can be subjected to the action of water boiling under high pressure, and thus thoroughly "digested," or cooked.

The danger of bursting these vessels caused him, in 1681, to in-

DENYS PAPIN.

vent and apply the *lever safety-valve*,[1] now an indispensable appurtenance to every steam-boiler.

17. In 1690 he constructed a working model of an engine, consisting of a steam-cylinder with a piston which was raised by steam-pressure, and which descended again when the condensation of the steam produced a vacuum beneath it.

This apparatus the inventor proposed to use as a motor for working pumps and for driving paddle-wheels; but he never built a successful working machine on this plan, so far as we can ascertain; and he did not then propose a separate boiler, but made the same vessel serve at once as a boiler, steam-cylinder, and condenser, evaporating water in the cylinder itself;[2] and, after raising the piston, removing the cylinder from the fire, or the fire from under the cylinder, to effect condensation by the gradual loss of heat by radiation.

18. The most important advance in actual construction was made by Thomas Savery.

The constant and embarrassing expense, and the engineering difficulties presented by the necessity of keeping the British mines, and

[1] Other forms of safety-valve had been previously used.

[2] "Recueil des diverses Pièces touchant quelques nouvelles Machines et autres Sujets philosophiques," M. D. Papin, Cassel, 1695.

particularly the deep pits of Cornwall, free from water, and the failure of every attempt previously made to provide effective and economical pumping machinery, were noted by Savery, who, July 25, 1698, patented the design of the first engine which ever was actually employed in this work.

THOMAS SAVERY.

A working model was submitted to the Royal Society of London, in 1699,[1] and successful experiments were made with it.

This engine is shown in Fig. 8, as described by Savery himself in 1702, in the "Miner's Friend."

L L is the boiler, in which steam is raised, and through the pipes *O O* it is alternately let into the vessels *P P*.

Suppose it to pass into the left-hand vessel first. The valve *M* being closed and *r* being opened, the water contained in *P* is driven out and up the pipe *S* to the desired height, where it is discharged.

The valve *r* is then closed, and also the valve in the pipe *O*. The valve *M* is next opened, and condensing water is turned upon the exterior of *P* by the cock *Y*, leading water from the cistern *X*. As the steam contained in *P* is condensed, forming a vacuum, a fresh charge of water is driven by atmospheric pressure up the pipe *T*.

Meantime, steam from the boiler has been let into the right-hand vessel *P*, the cock *W* having been first closed and *R* opened. The charge of water is driven out through the lower pipe and the cock *R*, and up the pipe *S* as before, while the other vessel is refilling preparatory to acting in its turn.

[1] "Transactions of the Royal Society," 1699.

The two vessels thus are alternately charged and discharged as long as is necessary. Savery's method of supplying his boiler with water was at once simple and ingenious.

The small boiler *D* is filled with water from any convenient source, as from the stand-pipe *S*. A fire is then built under it, and, when the pressure of steam in *D* becomes greater than in the main boiler *L*, a communication is opened between their lower ends and the water

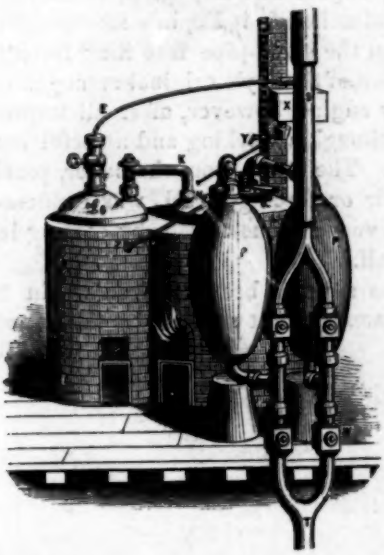


FIG. 8.—SAVERY'S ENGINE, A. D. 1699.

passes under pressure from the smaller to the larger boiler which is thus "fed" without interrupting the work. *G* and *N* are *gauge-cocks* by which the height of water in the boilers is determined, and these attachments were first adopted by Savery.

19. Here we find, therefore, the first really practicable and commercially valuable steam-engine. Thomas Savery is entitled to the credit of having been the first to introduce into general use a machine in which the power of heat, acting through the medium of steam, was rendered useful.

It will be noticed that Savery, like the marquis of Worcester, and like Porta, used a boiler separate from the water-reservoir.

He added to the "water-commanding engine" of the marquis the system of *surface condensation*, by which he was enabled to change his vessels when it became necessary to refill them; and the secondary boiler, which enabled him to supply the working boiler with water without interrupting its action.

The machine was capable of working uninterruptedly for a period of time only limited by its own endurance.

Savery never fitted his boilers with the safety-valve, although it was subsequently used on Savery engines by Desaguliers; and in deep mines he was compelled to make use of higher pressures than his rudely-constructed boilers could safely bear.

The introduction of his machines was, therefore, greatly retarded by the fear, among miners, of the explosion of his boilers; in fact, such explosion did occur on more than one occasion.

20. The Savery engine was improved, about 1716 or 1718, by Dr. Desaguliers, who attached to it Papin's safety-valve, and substituted a jet injection from the stand-pipe into the "forcing-vessels" for the surface condensation of Savery's original arrangement.

21. The Savery engine, however, after all improvement in design and construction, though a working and a useful machine, was still a very wasteful one. The steam from the boiler, passing into the cold, wet water-reservoir or forcing-vessel, was condensed in large quantity, and also to a very serious extent, by coming into actual contact with the water itself.

Papin, who has already been referred to, in 1707 proposed[1] to avoid this loss, to some extent at least, by the use of his piston, which

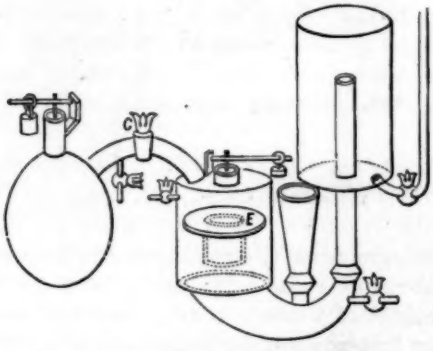


Fig. 9.—Papin's Steam-Engine, A. D. 1707.

he interposed between the steam and the water, as in Fig. 9, which is copied from a sketch given by Papin himself.

This engine is, in principle, a Marquis of Worcester engine, in which the piston *E* is introduced to separate the steam from the water which it impels, and thus to reduce the amount of loss by condensation.

This engine was never constructed, except experimentally, however, and is principally of interest in a history of the steam-engine from the fact that it was a useful suggestion to succeeding inventors.

Papin had, as early as 1698, abandoned his earlier but more ad-

[1] "Nouvelle Manière de lever l'Eau par la Force de Feu, mise en Lumière." Par M. D. Papin, Docteur en Médecine, Professeur en Mathematique à Cassel, 1707.

vanced project of a piston, driven by steam-pressure on one side, assisted by a vacuum produced on the other; and he can only be regarded, therefore, as an ingenious and intelligent though unfortunate projector, and not as a successful inventor, notwithstanding his acknowledged ability and learning.

THE LAW OF CONTINUITY.

By GEORGE ILES.

WHEN the details of knowledge had in modern times accumulated to so great an extent as to demand some organization of them into principles, thoughtful men cast about for some law which might serve to relate and connect together, in part at least, the multitude of facts and theories which were in an isolated and incoherent state.

At this important stage of scientific development, Galileo was the first to recognize the value of Plato's thought as to the continuous action of natural forces. By arranging in serial order the cases of a law, he showed that phenomena which might be supposed to be radically distinct were really due to one cause; and he said that, where links of connection were unknown, they should be sought for diligently.

Galileo, however, was too busy a man to work out many of the suggestions of the law of continuity, and it remained for Leibnitz to be the first to apply it extensively in the test of physical theories, and in the reduction of fragmentary knowledge to order and intelligibility. He affirmed that nothing passes from one state to another without passing through all intermediate states, and established the truth of his proposition by showing the absurdity of the contrary. If a change were to happen without the lapse of time, the thing changed must be in two different conditions at the same instant, which is manifestly impossible.

From this principle, for example, if it be known that a body at one moment had a temperature of 20°, and at another moment a temperature of 40°, it is certain that at some intervening moment its temperature was 30°. Although this law is so simple when stated as to seem almost axiomatic, yet its cases are frequently so obscure as to have caused much hesitation in its acceptance as a universal or even a widely-operating law. Some of its illustrations, lately discovered, are among the hardest-won triumphs of experimental skill, and have demanded the aid of the most refined modern apparatus.

A typical example of continuity has long been familiar to students of geometry; figures which may differ so much in graphic delineation

as the circle, the ellipse, parabola, and hyperbola, may be united by the insensible modifications of surface afforded by the inclination, more and more, of a plane dividing a cone asunder.

Similarly, in mechanics, the arc of a vibrating pendulum may be gradually enlarged by successive impacts until it becomes a circle. The part of a rotation differs generically from a complete one, yet it may approach infinitely near to it, and with only such a difference as exists between one arc and another slightly shorter.

The works on physics issued during the last century abound with distinctions which close and accurate investigations have since removed. Iron was once thought to be the only substance endowable with magnetism; now, not only all the metals, but all bodies whatever, are proved to present this polar force. In like manner, with respect to heat and electricity, conductors and non-conductors were ranged as two opposite classes; this disposition is still practically useful, since most substances conduct either very well or very ill; but it has given way as a precise statement of truth before the demonstration that all substances may be placed in unbroken order as to conductive power. For, while no material transmits either heat or electricity without some resistance, that resistance is in no case indefinitely great.

The transmission of light is another property which is not now confined within a narrow area; transparency is no longer attributed to a few bodies only—air, glass, and the like—it is extended to matter universally, experiment and reason both warranting the belief that any substance whatever, if reduced to a sufficiently thin film, would be pervious to light. Gold, one of the densest metals, can now be deposited by electricity in such tenuity as to be easily penetrated by the solar ray, and, although science is unable to give us any metal but gold in a translucent state, we know the degrees at which such light as passes through every member of the metallic catalogue is refracted. This curious piece of information has been attained by extending to the cases concerned a law, which, as far as experiment has gone, has been found true—namely, that the angle of a ray polarized by reflection always makes 90° with the angle of a refracted ray. Now, the particular angles at which lead, copper, and the rest, polarize light by reflection being observed, a simple calculation tells us how much deflection a beam may undergo in piercing metallic plates. This is an instance of how Science appropriates territory, one might deem ever to be undiscovered, by availing itself of the relationship of laws binding all things together, and interweaving the known and the unknown.

Chemists have taken their acids and alkalies, that were formerly adjudged as possessing qualities diametrically opposite, and now include them in one catalogue, no two consecutive members of which are much more than distinguishable in character. The same order

has also been adopted in the electro-chemical arrangement of metals. Upon the possibility of placing all bodies in a continuous list under the head of any property whatever—cohesion, elasticity, and so on—the opinion is now entertained that all matter is capable of receiving, holding, and giving forth, any kind of force.

The varieties of force themselves have been instructively reduced to a single basis—that of motion; electricity, gravity, light, and all the rest, are at present referred to the movement in particular orbits and planes of the ultimate particles which build up all masses. For any sort of force can be converted by suitable means into any other, and all into common mechanical motion. Now, as transformations of energy are incessant in Nature—changes whereby heat becomes electricity, electricity light, and light chemical action—it must be that there are intermediate phases which a body assumes while passing from the manifestation of one of these forces to another. It must be that the ordinary forms of force just named, which seem to be so broadly marked off from each other, must be really united in transmutation by processes of motion too unstable to be caught and detained by our comparatively rude methods of detection and arrest. The extremes of a series we see, the links between elude us.

The kinds of motion to which are given names in our works on physics are, perhaps, only the stable varieties of an indefinitely great number. The swiftness of the transitions from one stable form to another may explain and excuse the notion long held that the different kinds of force were individual entities, unrelated to each other.

Here one of the chief lessons taught us by the law of continuity comes in: we are confronted by a variety of seemingly isolated forces; we find them taking on indifferently one another's forms; and, although we know not how they do so, yet we can see the danger of over-estimating the apparent, while much more may be present though hidden from our sight. The comprehension of all the varieties of force under the one category of motion is hardly fraught with any deduction more suggestive than that which inclines us to acknowledge that mere permanence has hitherto unduly influenced our ideas of what the modes of motion may be in extent and diversity. The existence of electricity was unsuspected, except in the case of rubbed amber, until within a few generations; the fleeting character of the force evading the scrutiny of the majority of the acutest investigators of Nature who have lived.

The noble generalization of the conservation of energy affords another fact and hint of much value. It tells us of the radical identity of all sorts of force, whether as that of the descending clock-weight; or in a simple form of much fixity, as that of heat; or evanescent and easily convertible, as electricity; or intricate and with many paths of working, as chemical affinity; or beyond the reach of any but vague and general means of examination, as the forces of nerve and brain.

Every one of these is within the jurisdiction of the laws of mechanics, even when the motions are so exalted in degree and dignity as to seem of other stock than their real parents. Or, to change the metaphor, the tortuous labyrinth of the whole series diverges by clear and continuous avenues from one simple highway, where the elementary laws of motion are visibly obeyed.

The consistences of matter, as well as its properties, illustrate in a remarkable manner the principle of continuity. Sir William Herschel long ago ventured on general grounds to predict that the solid, liquid, and gaseous states of matter would be found to shade off imperceptibly into each other. Twenty years afterward, the labors of Prof. Andrews, of Belfast, proved the great astronomer right. By the most ingenious appliances, he detained for convenient inspection processes of transition from gas to liquid, which, in their ordinary progress, coalesce so abruptly as to seem instantaneous. In some familiar cases we can perceive changes of the same kind going on; as, for example, in the melting of wax we can follow the alteration from brittle hardness to plasticity, and thence to viscosity and liquefaction. From facts such as these, here very briefly indicated, has arisen the conviction that all matter can assume any of the three consistences. Faraday liquefied, by cold and great pressure, several of what had been called permanent gases, and improvements in the means of producing pressure and cold will doubtless enable us in the future to liquefy the remainder. Although the greatest heat we can bring to bear on carbon does not fuse it, still the tendency of our knowledge is to induce us to believe that coal in burning for a brief instant, too short for observation, exists in the liquid state. A second of time is divisible into millionths quite as perfectly as a geological cycle.

The thread of continuity has, in a variety of cases, been established in the laboratory. No two physical facts would seem to stand more decidedly apart than chemical union and mechanical admixture, yet we find them inextricably joined when we add sulphuric acid and water together. In all possible percentages do these liquids chemically combine, and this at variance with the generally-obeyed law of definite proportions. The same departure from the usual rule also obtains among other complex unions, and corroborates what first principles affirm—namely, that chemical forces are but intense and involved mechanical ones.

In the progress of science there has been much speculation as to the method by which light, electricity, and gravitation, are propagated through space. It is the old question again, "Can matter act where it is not?" Newton found the idea inconceivable, and imagined an ether as the vehicle of motions between the suns and planets of the universe. This position has been criticised by Mill, who says that inconceivableness is no test of truth, and who asserts, with a lack of his usual caution, that scarcely any living thinker of eminence now

doubts that matter can act where it is not. What light have recent researches shed upon this interesting question, heretofore little more than metaphysical?

The solar atmosphere has been found to extend to more than half a radius beyond its surface; at the top of its corona, high above the hydrogen, there are vast masses of a gas which emits a simple, green ray, not corresponding with that of any known substance. In auroral displays on earth, in the uppermost regions of our atmosphere, the same simple ray has been detected; whence it has been supposed that atmospheres are not restrictedly planetary nor solar, but continuous and cosmical; and that it may be a gas indefinitely rarefied that conveys to us through the depths of space not only light-motion, but the yet more inappreciable tremors of electricity and gravitation.

The ordinary definitions of the interstellar ether are open to the objections urged by Mill, because of a dread there seems to be abroad of ascribing materiality to it; while its infinitesimal materiality is not only within the bounds of possibility, but well agrees with the facts. All motion takes time; light has a measurable velocity; chemical action of the most violent kind and even explosions are not instantaneous. Were it otherwise, the hypothesis of no medium or of an immaterial one might be entertained. Now, the decidedness in amount of a body's weight as a mass, or in its particles, has no necessary connection with its efficiency as a medium of motion. Just the reverse: we find that as matter is smaller and lighter in its ultimate parts or gross masses, the more rapidly can it communicate motion, and the greater is its capacity for motion. It is a familiar fact that, in the use of machinery, a small wheel can, proportionately to its weight, contain and transmit more motion than a large one, the plain reason of which is that it can be driven at a higher peripheral speed, its smaller bulk causing less centrifugal strain at the axis than if it were larger.

Sound travels nearly four times faster in hydrogen than in air, and in quickness of elastic recoil it is, when compressed, preferable to air in the same degree. Its extraordinary chemical energy, far transcending that of denser gases, is a fact of parallel bearing.

If we can imagine a gas as much thinner than hydrogen as the square of light's velocity exceeds the speed of sound in hydrogen (about 4,000 feet a second), we have a reasonable presentation of what the luminous medium may be—its marvelous tenuity being vastly more than compensated by the mobility of its molecules. And, therefore, the most subtile aëriform fluid conceivable is of enormously more utility in propagating impulses from star to star than solid steel would be. The ether of space perhaps sustains some such relation to a gas as a gas does to a liquid; and the current disputes as to the materiality or immateriality of a cosmic medium recall very suggestively the days, not very distant, when wise men doubted the

materiality of air, and the still more recent times when it was found that gases other than air had existence.

Some further speculations, enkindled by the green ray observed in the sunshine, may be here presented as relevant to the subject. Dumas, the eminent French chemist, sought by very careful determination to prove that all atomic weights were exact multiples of that of hydrogen. He found them to be multiples of a number one-fourth that of hydrogen, whence the tenuous masses which lie above the hydrogen on the sun's surface are supposed to be one-fourth the specific gravity of the lightest gas we commonly know. And, as the spectrum it yields is the simplest known or even possible, it is thought that this new unit of the atomic scale may be primal matter, and the source of all material forms. This conjecture is not unsupported by other considerations, for, in the four kinds of stars regarded in the order of their brightness and heat, there is a progressively increasing variety of gases as they approach a lower temperature—a suggestion this as to the origin of our sixty-three so-called elements in chemistry.

In domains above the plane of physics, we can observe many beautiful cases of the law of continuity. On a window-pane in winter we can notice structural forces beginning their work where there has been, as far as we could see, no structure. We may breathe on the glass, and no microscope can there reveal any definite direction in the disposal of the moisture. Yet, from it a symmetrical architecture of frost slowly arises. We may take a crystal just deposited from a solution, break off a corner from it, and replace it in the liquid whence it came, when the damage will be accurately repaired.

Between the inorganic and the organic kingdoms of Nature the old partition-walls have at many points been removed. Formic acid, such as ants secrete, has been made artificially by the synthesis of its elements; and so have other products, formerly regarded as purely organic. Prof. Huxley maintains the opinion that, in the past, highly-complex chemical compounds have passed into the state of what he calls protoplasm, the simplest basis of organic life. The controversy about spontaneous generation is not whether the organic is contained and potential in the inorganic, but whether the transition can be artificially effected now.

Plants, like the fly-catcher, which closes on venturesome insects and absorbs their juices, show us how powers, commonly supposed to be exclusively animal, may be shared by members of the vegetable world. The sensitive-plant has something very like the nervous system which marks the highest types of life, for it not only shrinks when rudely touched, but also when exposed to fumes of chloroform. In the same direction points what in plants generally seems to parallel instinct in animals. If a layer of soil near the surface of the ground be unusually rich and moist, the rootlets in growth are spread almost wholly along that layer, while in any other case they descend.

The tendrils of vines find points for attachment an inch or two from their stems; in cellars and caverns the feeble sprouts grow toward the light which they seem to feel is their life.

Is not all this conformable to the law by which motion takes the path of least resistance, as in the case of the waters of a broken reservoir descending to a valley by the shortest channel; or discharges of electricity harmlessly betaking themselves to the earth through a purposely-exposed conductor?

Instinct, especially in insects, borders on and at times invades the higher realm of intelligence. The shapes of birds'-nests, wax-cells, and so on, are not rigidly invariable, but are always more or less adapted to circumstances. Glass rods have been placed in a bee-hive, and the little workers to avoid them have sprung all sorts of buttresses and arches, such probably as neither they nor any of their progenitors ever undertook before.

Natural history, in the discussions which have recently shaken the world, illustrates how difficult, if not impossible, is the task of trying to draw lines of demarkation, hard and fast, in Nature. The arguments *pro* and *con* as to what constitutes a true species might be gathered into a very bulky volume, and the end of the discussion is not yet.

The probability of truth, on the side of those naturalists who affirm the principle of continuity as explaining the genesis of species, has been strengthened by that principle being made the basis of the best method of zoölogical classification yet produced.

Profs. Huxley and Haeckel describe a tree of life: the main branches of it are the great classes; the divergent limbs, the families; and the minor branches, the species. The wide gaps between the groups of organisms now extant are in considerable measure bridged by recourse to fossils, and the suggestions of embryology—which science studies the phases an animal passes through from conception to birth, and observes the affiliations indicated in antenatal history.

As the gulfs existing between living things present the most formidable difficulty in the way of the reception of the principle of continuity in its broadest claims, it may be admissible here to present some of the explanations given by Lyell and others to account for the fact that so many links of genetic connection are missing. It is most important to a species that it should preserve and intensify some definite method of subsistence—a habit of diving, climbing, swimming, digging, or of catching some particular prey, or finding and living on some special plant. There is a natural premium set upon some expertness of this kind, which we must mark is very apt to run in a narrow groove; and there is a yet greater reward for any new expertness, the occupying of a new field of animal possibility, or an adaptation to circumstances changed by the great forces of Nature—as in the mighty revolutions brought about by astronomical and geological causes.

In periods of transition we can well imagine that an elasticity in stationary circumstances, usually all but dormant in an organism, comes into play with all its power; and hence that the type fit for the new conditions is, comparatively speaking, soon formed and fixed. We may thus understand how it is that a wide diversity among living forms has been brought about, and why it is that few fossils intermediate between them have been discovered. Some very striking ones have been unearthed, but it would be an unwarrantable digression to describe them in a paper of these limits.

The remote extremes which may be joined together by gentle and imperceptible modifications are well illustrated in the facts of ordinary growth. Newton had once to be taught that two and two make four, yet from that day to the culmination of his powers there was no abrupt accession of knowledge or insight. He came by steady advances from the ignorance of a babe to the full stature of the first physical philosopher in Europe.

All this teaches us the supreme importance of looking at things in their dynamic as well as in their static aspect; of regarding the mechanics not less earnestly than the geometry of Nature. For differences in degree may gradually accumulate until they become differences in kind. We have seen how various sources of obscurity may veil processes of genesis, and lead any but a minute and careful observer to mistake a new form for a new identity. We have noticed how the possession of qualities usually in extremes may conceal the fact that the qualities are general—as in the magnet, which is but an exaggerated case of any mass whatever.

We have noticed how the vast differences in the time required in transmutation may tend to confuse the similarity of two cases of a law. The embrowning of a pine fence in the course of years is due to the same cause which chars in a few minutes the same wood when used as fuel. We have remarked, also, the enormous differences in the stability of natural forces: some of them, as heat, are metamorphosed with great difficulty; others, as electricity, are of very weak permanence; and others, again, in whose existence we have good reasons to believe, are too evanescent to be detected by the keenest scrutiny.

It has also appeared that mere complexity of resultant lines, as simple forces interact, may yield the erroneous supposition that new and higher causes than the real ones have come into action.

It has been briefly stated how diverse properties merge into one another, and various consistencies overpass the bounds of common definition; and, leaving the region of fact for that of speculation, it has been shown how the principle of continuity may account for the genesis of our chemical elements, and the transfer of impulses across the diameter of the heavens.

All these facts, probabilities, and suggestions, lead to the convic-

tion that continuity is a universal law; that it prevails everywhere, and has prevailed throughout all time; that its present innumerable and intricate threads have been spun forth from the simplest conceivable state of matter and motion, which from the beginning have been subject to a uniform code of law—a code of law growing more complicated with time by the interaction and mutual influence of primitive principles.

The study of continuity presents many results very pertinent to the great question, "How has Nature assumed the infinite beautiful forms which engage our attention and admiration to-day?" The probabilities in favor of the solution offered by the evolution theory are much enhanced when we consider how insignificant in area, and transient in operation, are many of the bridges connecting together the islands and continents of forces and life.

As we trace out with great pains the unbroken links stretching between the most diverse facts and appearances, links which a cursory view would never discover, we find that that theory which supposes a community of origin and descent for all that now is, has a remarkable body of evidence adducible in its favor.

That Nature has arrived at its present state by the continuous action of forces such as are now at work around us, has become so widely-prevalent a conviction that Mill said, speaking of the inclusion of special laws in general ones convergently, that the question Science now asks is, "What are the fewest and simplest assumptions which, being granted, the existing order of Nature would follow?"

MODERN TROGLODYTES.

By FELIX L. OSWALD, M. D.

THE Troglodytes or Cave-dwellers of ancient Nubia belonged to a tribe which seems to have formed an intermediate link between the Semitic and Ethiopian races, but which has become entirely extinct before the second century of the Christian era. Between Sidi Elgor and Port Er-nassid (the ancient Berenice), on the shores of the Red Sea, Dr. Brehm examined many of the limestone-caverns which were the favorite haunts of these singular beings, and found no difficulty in distinguishing the bones of the Coptic and Arabian burial-places from the Troglodyte skeletons, which could be recognized by their demi-simian skulls, their attenuated brachial and femoral bones, and especially their narrow chests.

These peculiarities Dr. Brehm ascribes to the unnatural habits of the wretched cave-men, who, from cowardice or constitutional sloth, passed the greater part of their existence in the penetralia of their

foul burrows, while their neighbors preferred a manlier way of securing themselves against enemies and wild beasts, and saved themselves from the glow of the midsummer sun by cultivating shade-trees. "Herodotus speaks of persecutions," the doctor remarks, "but this fixed custom of theirs may perhaps be attributed to vicious habit, strengthened by hereditary transmission, quite as much as to necessity, for men can become fond of vitiated air, as they contract a passion for fermented drink or decayed food."

It seems really so, if we reflect on the hereditary perversity of millions of Europeans and North American citizens, who in the midst of social security, and without the excuse of the persecuted Nubians, insist on secluding themselves and their children in the foul atmosphere of tenement-houses, factories, and workshops, which might just as cheaply be supplied with pure as with warm air.

The air we breathe, which a great English physician calls gaseous food, may become impure to the degree of being *indigestible* to our lungs and utterly unfit for the performance of functions which are quite as important as those of our solid and fluid victuals. Dull headaches, nausea, loss of appetite and of the sense of smell, and the sadness produced by the unsatisfied hunger after oxygen, are only incidental and secondary evils; the great principal curse of the troglodyte-habit is its influence on the respiratory organs. In 1853, when Hanover and other parts of Northern Germany were visited by a very malignant kind of small-pox, the great anatomist Langenbeck tried to discover "the peculiarity of organic structure which disposes one man to catch the disease while his neighbor escapes .... I have cut up more human bodies than the Old Man of the Mountain with all his accomplices," he writes from Göttingen in his semi-annual report, "and, speaking only of my primary object, I must confess that I am no wiser than before. But, though the mystery of small-pox has eluded my search, my labors have not been in vain; they have revealed to me something else—the origin of consumption. I am sure now of what I suspected long ago, viz., that pulmonary diseases have very little to do with intemperance or with erotic excesses, and much less with cold weather, but are nearly exclusively (if we except tuberculous tendencies inherited from *both* parents, I say *quite* exclusively) produced by the breathing of foul air. The lungs of all persons, minors included, who had worked for some years in close workshops and dusty factories, showed the germs of the fatal disease, while confirmed inebriates, who had passed their days in open air, had preserved their respiratory organs intact, whatever inroads their excesses had made on the rest of their system. If I should go into practice and undertake the cure of a consumptive, I should begin by driving him out into the *Deister* (a densely-wooded mountain-range of Hanover), and prevent him from entering a house for a year or two."

The ablest pathologists of the present time incline to the same

view. "There *is* a cure for consumption," says Dio Lewis, "though I doubt if it will ever become popular. Even in its advanced stages the disease may be arrested by *roughing it;* I mean by adopting savage habits, and living out-doors altogether, and in all kinds of weather."

That low temperature in open air does not injure our lungs has been recognized even by old-school physicians, who now send their patients to Minnesota and Northern Michigan quite as often as to Florida; and is conclusively proved by the fact that of all nations of the earth, next to the inhabitants of the Senegal highlands, the Norwegians, Icelanders, and Yakuts of Northern Siberia, enjoy the most perfect immunity from tubercular diseases. Dry and intensely cold air preserves decaying organic tissue by arresting decomposition, and it would be difficult to explain how the most effective remedy came to be suspected of being the cause of tuberculosis, unless we remember that, where fuel is accessible, the disciple of civilization rarely fails to take refuge from excessive cold in its opposite extreme—an overheated artificial atmosphere—and thus comes to connect severe winters with the idea of pectoral complaints.

There is a rather numerous class of beasts whose lungs seem able to adapt themselves to an atmosphere almost devoid of oxygen, but the human animal and the Quadrumana do not belong to that class. Monsieur de la Motte-Baudin, who was connected with the scientific staff of the *Jardin des Plantes* as their "menagerie-doctor" for more than twenty years, never omitted to dissect his deceased patients before turning them over to the taxidermist, and invariably found that *all* monkeys had succumbed to some variety of phthisis, while the lungs of the badgers, bears, and foxes, were perfectly sound. The three last-named animals are natural cave-dwellers, and have been provided with organs especially contrived to resist the effluvia of their burrows; while the *Simiæ*, like man, are open-air creatures, whose proper atmosphere is the cordial air of woodlands.

Among the natives of Senegambia pulmonary affections are not only nearly but absolutely unknown; yet a single year passed in the overcrowded man-pens and steerage-hells of the slave-trader often sufficed to develop the disease in that most virulent form known as galloping consumption; and the brutal planters of the Spanish Antilles made a rule of never buying an imported negro before they had "tested his wind," i. e., trotted him up-hill and watched his respirations. If he proved to be "a roarer," as turfmen term it, they knew that the dungeon had done its work and discounted his value accordingly. "If a perfectly sound man is imprisoned for life," says Baron d'Arblay, the Belgian philanthropist, "his lungs, as a rule, will first show symptoms of disease, and shorten his misery by a hectic decline, unless he should commit suicide."

Our home statistics show that the percentage of deaths by con-

sumption in each State bears an exact proportion to the greater or smaller number of inhabitants who follow in-door occupations, and is highest in the factory districts of New England and the crowded cities of our central States. In Great Britain the rate increases with the latitude, and attains its maximum height in Glasgow, where, as Sir Charles Brodie remarks, windows are opened only one day for every two in Birmingham, and every three and a half in London; but going farther north the percentage suddenly sinks from twenty-three to eleven, and even to six, if we cross the fifty-seventh parallel, which marks the boundary between the manufacturing counties of Central Scotland and the pastoral regions of the north.

It is distressingly probable, then, to say the least, that consumption, that most fearful scourge of the human race, is *not* a "mysterious dispensation of Providence," nor a "product of our outrageous climate," but the direct consequence of an outrageous violation of the physical laws of God. Dyspepsia (for which also open-air exercise is the only remedy), hypochondria, and not only obstruction but destruction of the sense of smell—"knowledge from one entrance quite shut out"—will all be pronounced mere trifles by any one who has witnessed the protracted agony of the Luft-Noth, as the Germans call it with horrid directness—the frantic, ineffectual struggle for life-air. Dr. Haller thought that, if God punishes suicide, he would make an exception in favor of consumptives; and there is no doubt that, without the merit of martyrdom, the victim of the cruel disease endures worse than ever Eastern despot or grand-Inquisitor could inflict on the objects of his wrath, because the same amount of torture in any other form would induce speedier death.

But not only the punishments but also the warnings of Nature are proportioned to the magnitude of each offense against her laws. Injurious substances are repulsive to our taste, incipient exhaustion warns us by a feeling of hunger or weariness, and every strain on our frame that threatens us with rupture or dislocation announces the danger by an unmistakable appeal to our sensorium. How, then, can it be reconciled with the immutable laws of life that the greatest bane of our physical organism overcomes us so unawares that consumption is proverbially referred to as the insidious disease? Should it really be possible that Nature has failed to provide any alarm-signals against a danger like this? The truth is, that none of her protests are more pathetic or more persistent than those directed against the habit that is fraught with such pernicious consequences to our respiratory organs.

It is probable that some of the victims of our numerous dietetic abuses have become initiated to these vices at such an early period of their lives that they have forgotten the time when the taste of tea and alcohol seemed bitter, or the smell of tobacco produced nausea; but I am certain that no man gifted with a moderate share of memory,

who has grown up in the pest atmosphere of our city tenements, school-rooms, and workshops, can forget the passionate yearnings of his childhood for the free air of the woods and mountains; the wild outcry of his instinct against the process that inoculated him with the seeds of death, and stunted the development of his most vital faculties. The remorselessness of the pagan Chinese, who smother the life-spark of their infants in the swift embrace of the river-god, is mercy itself compared to the cruelty of Christian parents who suffocate their children by the slow process of stinting their life-air, through years and years of confinement in dungeons to which an enlightened community would not even consign their malefactors.

Honest Jean Paul relates that he used to secure a seat in a certain corner of an overcrowded village schoolhouse, where a knot-hole in the wall established a communication with the outer world. Through this orifice he imbibed comfort and inspiration as from a flask, but conceived conscientious scruples against the practice, as he never could indulge without becoming conscious of a temptation to abandon his old parents and his home, and join a troop of wood-cutters or gypsies, not from any vagrant tendencies, or want of dutiful sentiments, but from an almost irresistible desire to make the luxury of fresh air a permanent blessing. "I knew they would charge me with black ingratitude, if I should run away," he says. "Good God! how I longed to prove my affection by working for them in wind and weather, fetching in cord-wood from the woods and splitting it into the nicest, handiest pieces, carrying messages over the snow-covered mountains and be back in half the time any one else could make the trip—do anything that would save me—not from my books, but from that glowing Moloch of a big stove, and that stifling, soul-stifling smell of our dungeon!"

Even to the most inveterate believer in natural depravity this might suggest a doubt whether the repugnance of children to study may not be founded on a physical virtue rather than on moral perverseness. To whatever is really beneficent we are commonly drawn by natural attraction, and whatever appears violently repulsive to youthful minds may be justly suspected of containing more of evil than of good. The very disciple of Socrates who used to run sixteen miles a day to hear the *ἄριστος ἰατρων* (best of physicians), would have hesitated to purchase physic for his soul at the price of physical health; and we cannot blame our children for being unable to reconcile the precepts they hear with those they feel, and giving way now and then to the more consistent and more logical prompter.

The farmer's boy may look forward to each afternoon and each summer vacation as a refreshing interlude, and to the last term of his school-years as the last act of the tragedy; but in cities the end of the school-room bondage is too often the beginning of the endless slavery which awaits the young apprentice of the workshops, facto-

ries, and counting-houses. In Northwestern Europe and the Eastern States of North America, eleven million human beings, a fourth of that number minors, are performing their daily toil in an atmosphere that saps the vigor of their souls and bodies more effectually than a diet of potatoes and water could do it in the same time. A full third of the cotton-spinners of Lancashire and Massachusetts are girls and boys in their teens! They do not complain to a stranger, unless he should be able to interpret the language of their haggard faces and weary eyes; but no one who has fathomed the depth of their misery will charge me with exaggeration if I say that, to the vast majority of the unfortunates, loss of feeling and of reason would be a blessing. What *do* they feel but unsatisfied hunger in a hundred forms, and what can reason tell them but that they have been defrauded of their birthright to happiness; that not only their opportunity but their capacity for enjoyment is ebbing away; and that, whatever after-years may bring, their life has been robbed as a day of its morning or a year of its spring-time?

The opium-habit may be acquired in less than half a year, and the natural repugnance to alcohol and tobacco is generally overcome after four or five trials; but the factory-slave has to pass through ten or fifteen years of continual struggle against his physical conscience, before the voice of instinct at last becomes silent, and the painful longing for out-door life gives way to that anæsthesia by which Nature palliates evils for which she has no remedy. In more advanced years the habit becomes confirmed, and we find old *habitués* who actually enjoy the effluvia of their prisons, and dread cold air and "drafts" as they would a messenger of death. They avoid cold instead of impurity, just as tipplers on a warm day imagine that they would "catch their death" by a draught from a cool fountain, but never hesitate to swallow the monstrous mixtures of the liquor-vender.

Rousseau expresses a belief that any man, who has preserved his native temperance for the first twenty-five years, will afterward be pretty nearly proof against temptation, because very unnatural habits can only be acquired while our tastes have the pliancy of immaturity, and I think the same holds good of the troglodyte-habit: no one who has passed twenty or twenty-five years in open air can be bribed very easily to exchange oxygen for miasma.

Shamyl-ben-Haddin, the Circassian hero chieftain, who was captured by the Russians in the winter of 1864, was carried to Novgorod and imprisoned in an apartment of the city armory, which resembled a comfortable bedchamber rather than a dungeon, and was otherwise treated with more kindness than the Russians are wont to show their prisoners, as the Government hoped to use his influence for political purposes. But a week after his arrival in Novgorod the captive mountaineer demanded an interview with the commander of the armory, and offered to resign his liberal rations and subsist on bread and cab-

bage-soup like the private soldiers of his guard, and also to surrender some valuables he had concealed on his person, on condition that they would permit him to sleep in open air. One more week of such nausea and headache as the confinement in a closed room had caused him, would force him to commit suicide, he said, and, if his request was refused, God would charge the guilt of the deed on his tormentors. After taking due precautions against all possibility of escape, they permitted him to sleep on the platform in front of the guard-house; and Colonel Darapski, the commander of the city, informed his government in the following spring that the health and general behavior of his prisoner were excellent, but he had slept in open air every one of the last hundred nights, with no other covering but his own worn-out mantle, and a woollen cap he had purchased from a soldier of the guard to keep his turban from getting soiled by mud and rain.

General Sam Houston, the liberator of Texas, who had exiled himself from his native State in early manhood, and passed long years, not as a captive, but as a voluntary companion of the Cherokee Indians, was ever afterward unable to prolong his presence in a crowded hall or ill-ventilated room beyond ten or twelve minutes, and described his sensation on entering such a locality as one of "uneasiness, increasing to positive alarm, such as a mouse may be supposed to feel under an air-pump."

The cause of this uneasiness is less mysterious than our nature's wonderful power of adaptation that can help us ever to overcome it. The elementary changes in the human body are going on with such rapidity that the waste of tissue and organic fluids is only partially retrieved by the digestible part of the substances which we feed to the abdominal department of our laboratory twice or thrice in twenty-four hours. The difference is made up by the labors of the upper or pectoral department, which renews its supply of raw material independently, or even in spite of our will, twenty times per minute, or 70,000 times in twenty-four hours! With every breath we draw we take into our lungs about one pint of air, so that the quantity of *gaseous food* thus consumed by the body amounts in a day to 675 cubic feet. The truth, then, is that eating and drinking may be considered as secondary or supplementary functions in the complicated process performed by that living engine called the animal body, while the more important task falls to the share of the lungs. The stomach may suspend its labors entirely for twenty-four hours without serious detriment to the system, and for two or three days without endangering life, while the work of respiration cannot be interrupted for six minutes without fatal consequences.

The first object of respiration is to introduce elements needed in the preparation of blood, the second to remove gaseous carbon and other secretions of the air-cells. The deleterious consequences, therefore, of breathing the same air over and over again arise not only

from the exhaustion of oxygen, but also from the circumstance that the confined atmosphere may become azotized or surcharged with carbon to the limit of its absorbing powers, just as water, after being saturated with certain percents of salt or sugar, refuses to dissolve any further additions. The act of reinspiring air, which has already been subjected to the process of pulmonary digestion, is thus precisely analogous to the act of a famished animal devouring its own fæces, and if performed habitually cannot fail to be attended with equally ruinous consequences. Corruption of the alimentary ducts would surely ensue in the latter (supposed) case, putrefaction of the respiratory organs *does* follow in the other. Working-men employed in localities whose azotized atmosphere is loaded besides with particles of flying cotton-fibre, metallic dust, or fatty vapors, inspire substances which are just as indigestible to their lungs as mercury and alcohol are to their stomachs, and like these cause a rapid deterioration of the tissues in proximity to which they are deposited.

The only wonder, then, is how Nature can resist outrages of this kind for any length of time; and it is a curious reflection to think what amounts of hardship of the primitive sort, such as hunger, fatigue, cold, heat, deprivation of sleep, etc., a healthy savage might accustom himself to, if he tried as hard as the poor children of civilization try to wean themselves from their hunger after life-air!

Can necessity be—we will not say an excuse, but—an explanation of such systematic self-ruin? We must utterly refuse to believe it. Wherever men barter life for bread, there is a violent presumption that they do not know what they are doing; for against recognized health-destroyers even the poorest of the poor will rebel with a promptitude that vindicates the dignity of human nature under the most abject conditions of bondage. Let a railroad contractor be caught in the trick of adulterating his flour with chalk or his sugar with alum, and see how quickly his navvies will leave him; or observe how firmly reckless Jack Tar insists on his anti-scorbutic raspberry-vinegar! Miners have left a colliery *en masse*, because the owner shirked his duty of providing safety-lamps; and the very negro slaves of a South Carolina plantation attempted the life of their master, who stinted their allowance of quinine brandy which his father had issued them to counteract the miasmatic tendencies of the rice-swamp.

Neither is it possible to suppose that want of hygienic education can be the origin of such ignorance; for Nature does not wait for the scientist to inform her children on questions of such importance. All normal things are good, all evil is abnormal; vice is a consequence of ignorance only in so far as it is a result of perverse education, and the troglodyte-habit is the direct offspring of mediæval monachism. Until after the fourth century of the Christian era, habitual in-door life between closed walls was known only as the worst form of punishment. Though the Greeks and Romans were familiar with the manu-

facture of glass, they never used it to obstruct their windows; in all the temples, palaces, and dwelling-houses of antiquity, the apertures provided to admit light admitted fresh air at the same time. The *tuguria* of the Roman peasants were simply arbors; and the domiciles of our hardy Saxon forefathers resembled the log-cabins of Eastern Tennessee—rough-hewed logs laid crosswise, with liberal interspaces that serve as windows on all sides except that opposed to the prevailing wind, north or northwest, where they are stopped with moss.

Men had to be utterly divorced from Nature before they could prefer the hot stench of their dungeons to the cool breezes of heaven, but our system of ethics has proved itself equal to the task. For eighteen hundred years our spiritual guides have taught us to consider Nature and everything natural as wholly evil, and to substitute therefor the supernatural and the artificial, in physical as well as in moral life. The natural sciences of antiquity they superseded by the artificial dogma, suppressed investigation to foster belief, substituted love of death for love of life, celibacy for marriage, the twilight of their gloomy vaults for the sunshine of the Chaldean mountains, and their dull religious "exercises" for the joyous games of the *palæstra*. This system taught us that the love of sport and out-door pastimes is wicked, that the flesh has to be "crucified" and the buoyant spirit crushed to make it acceptable to God; that all earthly joys are vain; nay, that the earth itself is a vale of tears, and the heaven of the Hebrew fanatic our proper home.

"The monastic recluse," says Ulric Hutten, "closes every aperture of his narrow cell on his return from midnight prayers, for fear that the nightingale's song might intrude upon his devotions, or the morning wind visit him with the fragrance and the greeting of the hill forests, and divert his mind to earthly things from things spiritual. He dreads a devil wherever the Nature-loving Greeks worshiped a god." These narrow cells, the dungeons of the Inquisition, the churches whose painted windows excluded not only the air but the very light of heaven, the prison-like convent-schools and the general control exercised by the Christian priests over the domestic life of their parishioners, laid the foundation of a habit which, like everything unhealthy, became a second nature in old *habitués*, and gave birth to that brood of absurd chimeras which, under the name of "salutary precautions," inspire us with fear of the night air, of "cold draughts," of morning dews, and of March winds.

I have often thought that *mistrust in our instincts* would be the most appropriate word for a root of evil which has produced a more plentiful crop of misery in modern times than all the sensual excesses and ferocious passions of our forefathers taken together. What a dismal ignorance of the symbolic language by which Nature expresses her will is implied by the idea that the sweet breath of the summer night which addresses itself to our senses like a blessing from heaven could be injurious! Yet nine out of ten guests in an overheated ballroom

or travelers in a crowded stage-coach will protest if one of their number ventures to open a window after sundown, no matter how glorious the night or how oppressive the effluvia of the closed apartment. Pious men they may be, and most anxious to distinguish good from evil, but they never suspect that God's revelations are written in another language than that of the Hebrew dogmatist. Here, as elsewhere, men suppress their instincts instead of their artificial cravings. If we have learned to interpret the fact that a child whose mind is not yet biased by any hearsays is sure to prefer pure and cold air to the miasmatic "comfort" of a close room, the troglodyte-habit will disappear, as intemperance will vanish if we recognize the significance of that other fact—that to every beginner the taste of alcohol is repulsive, and that only the tenth or twelfth *dosis* of the obnoxious substance begins to be relished; just as the Russian stage-conductor relishes the atmosphere of his ambulant dungeon, whatever may have been his feelings of horror on the first trip.

If ever we recognize a truth which was familiar enough to the ancients, but seems to have been forgotten for the last ten or twelve centuries, viz., that our noses were given us for some practical purpose, the architecture of our dwellings, our factories, school-rooms, and places of worship, will be speedily corrected; and even the builder of an immigrant-ship will find a way to modify that floating Black Hole of Calcutta called the steerage. Prisons, too, will be modeled after another plan. Our right to diet our criminals on the ineffable mixture of odors which they are now obliged to accept as air depends on the settlement of the question whether the object of punishment is reform or revenge? In the latter case the means answer the purpose with a vengeance indeed: in the first case there is no more excuse for saturating the lungs of a prisoner with the seeds of tuberculosis than there would be for feeding him on trichinæ or inoculating him with the leprosy-virus.

The exegesis of consumption very nearly justifies Michelet's paradox—that the greatest evils might be easiest avoided. "There is no excuse for famine," says Varnhagen von Ense; "we could all live in clover if we did not misapply a large portion of our arable land to the production of tobacco, opium, and other poisonous weeds, and send ship-loads of our breadstuffs to the distillery. I am sure that if the spontaneous productions of the soil furnished us mountains of grain and rivers of honey, we would still manage to use it up in the manufacture of intoxicating poisons, and complain of hunger as before. If any one should doubt this, let him reflect on the fact that, while we are surrounded by a respirable atmosphere of more than 800,000,000 cubic miles, *civilization has contrived a famine of air!*"

THE SYSTEM OF SIRIUS,[1]

AND SOLAR SYSTEMS DIFFERENT FROM OURS.

By CAMILLE FLAMMARION.

EACH of the stars which glitter in the depths of space is a voluminous and massive sun like that which gives light to our earth. Distance alone reduces them to the appearance of fixed points. If we could approach any one of them we should experience the same impression as in passing from Neptune to the sun; the star would increase in size as we should approach it; it would soon exhibit a circular disk and continue to increase its proportions until they would be as large as the sun; finally, this luminous disk, continuing to increase in consequence of our approach, would expand and present itself as a fiery furnace filling the entire heavens—a colossal blaze, under which we would be reduced to nothing, melted like wax, vaporized like a drop of water dropped on red-hot iron! Such is every star in the heavens.

Each sun in space has its special sphere of attraction, a sphere which extends to the limit of neutralization by another. This attraction diminishes in the inverse ratio of the square of the distances, but never becomes absolutely nothing. At the distance of Neptune the solar attraction is 900 times less than at the distance of the earth. While the earth if it were stopped in its course would fall toward the sun 294 hundred-thousandths of a metre during the first second of time, Neptune would fall only 327 hundred-millionths of a metre in the same time. At the aphelion distance of the comet of 1680 the fall toward the sun is only the minute distance of 416 hundred-billionths of a metre during the first second of time. This attraction continues thus to decrease as the distance increases. But, at the same time, if a body moves in the direction of one of the neighboring stars, it begins immediately to receive its influence. The star nearest us is at a distance 210,000 times greater than that which separates the earth from the sun, or eight trillions of leagues; it is the star Alpha Centauri, a brilliant double star whose orbit and mass I have calculated. This mass is equal to the half of that of the sun; it happens that if one could travel from the sun to this star a point would be reached where the attraction of the two would neutralize each other; this point is three-quarters of the distance which separates us, that is, six trillions of leagues from our sun, or, what is the same, two trillions of leagues from Alpha Centauri, the whole distance being eight trillions. At that point, a celestial body, a comet, would hesitate as to which course to pursue, would weigh nothing, would

[1] Translated from the French by P. A. Towne.

stop in its flight; but the feeblest outward influence would be felt, throwing it either into the sphere of attraction of our sun or into that of Alpha Centauri.

This sun called Centaurus is located in the southern sky, near the antarctic pole. It appears to us in the form of a bright star of the first magnitude. The sun nearest to us, next after this, is situated in the northern sky, in the constellation Cygnus, or the Swan. It is famous as 61 Cygni. Its distance is 400,000 times the radius of the earth's orbit, or about fifteen trillions of leagues. I have often observed this star: it is just visible to the naked eye, but to the telescope it is double, as the preceding, only its components do not move around each other, a conclusion which has much surprised me, although arrived at by comparing all the observations made during the last hundred years; its mass, therefore, cannot be determined. But, however that may be, the fact which should impress us is that the distances which separate the suns of the universe are reckoned not by millions, nor by billions, but by trillions of leagues.

The most brilliant star of our sky, SIRIUS, is a sun whose volume, judging from its light, should be 2,600 times larger than that of our sun. Its distance is about 897,000 times thirty-seven millions, that is about thirty-three *trillions* of leagues.

Let us mention again among "our neighbors" the sixty-second of Ophiuchus, situated near the equator. I have calculated that it weighs about *three times as much as our sun*, that is, 900,000 times more than the earth. Its distance is 1,400,000 times the semi-diameter of the earth's orbit, that is, fifty-four trillions of leagues.

Astronomers, since the time of Kepler, agree in admitting that each of the countless suns that fill infinite space is the centre of a system analogous to the planetary system of which we form a part. Each of these suns that we see in the sky shows to us a luminous fireside around which other human families are gathered. Our eyes are too feeble to see these unknown planets. The most powerful of our telescopes do not yet reach down to these depths. But Nature concerns itself neither with our eyes nor with our telescopes, and so, beyond the boundaries that stop the flight of our tired conceptions, she continues to display her boundless and magnificent works.

However, the hour has come when these planetary systems different from ours cease to slumber in the domain of hypothesis. In spite of the telescope, celestial mechanics have already revealed the existence of obscure stars, invisible in the rays of these distant suns, but which affect them in their proper movements across immensity; and already powerful telescopes have contemporaneously recognized several among the stars known before to exist only in hypothesis.

One of the most splendid conquests of sidereal astronomy has been the discovery of the system of Sirius, made some fifteen years since. For a long time, from careful measures of its position, it has been

remarked that this brilliant star is slowly moving in space, like all the other stars, but that its proper movement is not uniform; and Bessel announced, thirty years ago, that at some time there would be discovered, without doubt, a world of its system moving around it and disturbing it in its progress. This discovery was made in 1862. The companion of Sirius was then almost exactly on the eastern side, quite small, and buried in the rays of the star. Since that year it has been constantly watched by the aid of powerful instruments, and it is seen to slowly gravitate around the Sirian sun.

But this companion certainly does not follow the theoretic orbit calculated to correspond to the perturbations noted in the proper movement of the brilliant star. Differences more and more marked are shown between the calculated ellipse and the observed ellipse. The following is the orbit calculated by the German astronomer Auwers in 1864 to correspond with recognized perturbations:

Passage by lower apsis	1793.890
Annual movement	70.28475
Period.....years	49.418
Eccentricity	0.6010

The last orbit calculated by Auwers, placed in the form of the orbits of double stars, and given as definitive, is the following:

Perihelion passage	1843.275
Longitude of node	61°.57,8
Angle between node and perihelion	18°.54,5
Inclination	47°.8,7
Eccentricity	0.6148
Semi-major axis	7″.331
Period.....years	49.399

From these elements, the limits of distance ought to be 2.31″ at 302.5° in 1841, and 11.23″ at 71.7° in 1770, and the ephemeris is—

1862	85°.4	10″.10	1874	65°.0	10″.95
1865	79°.9	10″.78	1876	62°.1	10″.59
1868	75°.0	11″.15	1878	58°.4	10″.05
1871	70°.3	11″.20	1880	54°.2	9″.33

But, in making out my "Catalogue of Double Stars in Movement," I have found that all the observations on the satellite of Sirius give the following means for each year since its discovery:

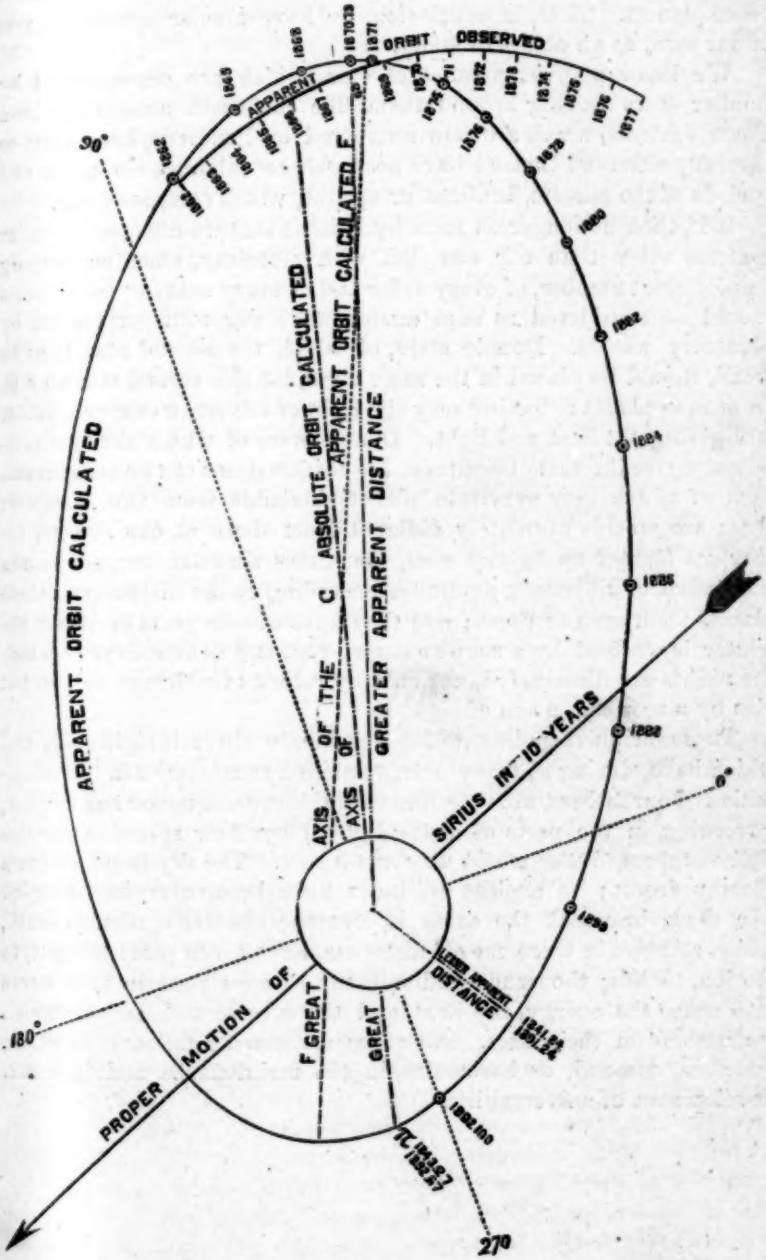
1862	84°.6	10″.08	1870	65°.0	12″.06
1863	82°.2	9″.84	1871	63°.0	11″.79
1864	79°.0	10″.33	1872	61°.3	11″.34
1865	76°.7	10″.56	1873	62°.7	11″.33
1866	75°.0	10″.61	1874	58°.5	11″.18
1867	73°.9	10″.39	1875	55°.5	11″.30
1868	70°.4	11″.18	1876	55°.2	11″.51
1869	72°.3	10″.92	1877	51°.0	11″.40

Pardon these figures! But they form the basis of the reasonings which constitute the groundwork of this article, and it is essential to consider them in order to know on what to rely in discussing the system of Sirius. In comparing these last numbers with those of the preceding ephemeris, we see at the first glance that the angle diminishes more rapidly than had been announced, while the distance has continued to increase since 1870 instead of having attained its maximum on that year, as the orbit of Auwers indicated. It is still further shown by the diagram I have constructed that the arc of the observed orbit crosses the calculated orbit about 1868 and is projected outside of it, pursuing a wholly different curve which must be larger than the orbit traced and less eccentric.

If the observed motion were the mean motion, the revolution of the satellite would be accomplished in a period of about one hundred and sixty-seven years. But the arc passed is yet too small to allow any positive conclusion, and, as the observed perturbations of Sirius demand a period of forty-nine years, we are brought to the conclusion that the observed companion continues to accelerate its motion and will be found in the west of Sirius in 1892, or else there is another body causing perturbation nearer Sirius, and moving more rapidly.

We should reserve all conclusions in regard to the existence of these other satellites, as well as all difference of period between the observed orbit and the calculated orbit; but the inevitable conclusion is, that the observed positions do not correspond with those of the ephemeris, and that the orbit thence resulting differs from the calculated orbit.

By the aid of all the observations I have constructed the figure, which shows the movement of the observed planet from 1862 to 1877. The central disk represents Sirius; the four cardinal points are indicated by dotted lines; the proper movement of Sirius in space is marked by the large arrow, whose length corresponds exactly to this movement during ten years (the figure is drawn to the precise scale of ten millimetres for a second). If the small star discovered in 1862 to the east of Sirius did not belong to it, if it was situated in the depths of space far beyond, it would have remained fixed, and Sirius would have moved from it in the direction indicated by the arrow. But, on the contrary, it belongs to Sirius, accompanies that sun in its progress as the earth accompanies its sun, and turns around it in an elliptic orbit. It has yet traversed, from 1862 to 1877, only the line marked on the figure—a curve not long enough to enable us to calculate the remainder of its orbit. As it is seen, this star is quite small by the side of Sirius, but still larger than Jupiter relatively to our sun. Is it an immense planet, totally opaque and shining only by reflection of the light of Sirius? This is not probable; it must still be self-luminous just as our own earth was during so many ages. It does not correspond exactly to the observed perturbations, a fact which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proves that the system of Sirius certainly contains other worlds yet unseen. Our lamented friend Goldschmidt believed he saw three other planets. Thus, in conclusion, we have a solar system, outside of our own, as an object of study.

We know a great number of stars which are accompanied by smaller stars moving around them like the earth around the sun. These systems, which are now numbered by hundreds, have been so carefully observed that we have been able to calculate the orbits and periods of the planets, brilliant or opaque, which compose them.

It is, then, no longer on mere hypothesis that we can speak of solar systems other than our own, but with certainty, since we already know a great number, of every order and of every nature. Single stars should be considered as suns analogous to our own, surrounded by planetary worlds. Double stars, of which the second star is quite small, should be placed in the same class, for this second star may be an opaque planet reflecting only the light of the large one, or a planet still giving out heat and light. Double stars of which the two components give the same brightness are combinations of two suns around each of which may gravitate planets invisible from this distance; these are worlds absolutely different from those of our system, for *they are lighted up by two suns*, sometimes simultaneous, sometimes successive, of different magnitudes, according to the distances of these planets from each of them; and they have double years of which the winter is warmed by a supplementary sun, and double days of which the nights are illuminated, not only by moons of different colors, but also by a new sun, a sun of night!

Those brilliant points which sparkle in the midnight sky, and which have, during so many ages, remained as mysteries in the imagination of our fathers, are therefore *veritable suns*, immense and mighty, governing, in the parts of space lighted by their splendor, *systems different from that of which we form a part.* The sky is no longer a gloomy desert; its ancient solitudes have become regions peopled like those in which the earth is located; obscurity, silence, death, which reigned in these far-off distances, have given place to light, to motion, to life; thousands and millions of suns pour in vast waves into space the energy, the heat, and the diverse undulations, which emanate from their fires. All these movements follow each other, interfere, contend, or harmonize, in the maintenance and incessant development of universal life.

THE DIFFERENCES OF THINGS.

By JOHN W. SAXON.

COULD a man do himself up into a mathematical point and throw himself into the middle of infinite empty space, wherever that is, he would be surprised at the flatness of life under such circumstances. Infinite empty space is absolute *sameness.* It is, so far as I have traveled the field of mental possibilities, the only specimen of the thinkable or the unthinkable of which we can say, "It is all alike."

Should we melt up the matter which is supposed to be scattered throughout infinite space, and then, by increased heat, turn it into gas, and expand it till all the systems of the universe became one infinitely-extended and equally-distributed universe of intermingled gases, we should have about as little variety as in the case of empty space.

Having unshackled the universe, and brought chaos back again, having secured a condition somewhat like that in which the advocates of the nebular theory suppose it to have been, consider what a dull time we should have if we were unable to find some little nook outside of infinite space, and, as a result, be obliged to amuse ourselves with such monotonous surroundings! It would be as wearisome as staring day after day at a blank wall without so much as a rain-streak on it.

But Nature seems to have understood that variety is not only "the spice of life," but life itself; and no sooner does she get in hand her raw material, than she sets herself to the work of creating *differences.* True, some astronomers reject the nebular theory; but, if not true, it will serve as an illustration. It seems to have been the great work of Nature to multiply differences. For instance, there was a time or an eternity in which Nature turned out her first owl, just as the first patent Yankee washing-machine must have had its day. But the inventors of the owl and of the washing-machine have gone on differentiating with unlike results. Most of the washing-machines are at rest. The fittest even scarcely survives. The owls are hooting still in varieties uncounted, and if, here and there, a specimen, discouraged and disgusted with the "modern improvements" of the Cainozoic period, gave up the ghost, and laid himself away with the old saurians —his Darwinian ancestors—he now finds himself resurrected, his bones neatly wired together, and the human owls hooting over him still. Like the immortal Webster, he "still lives" as a witness of Nature's wonderful resources as a differentiator—a difference-maker.

But let us look further into Nature's method of creating varieties. Shortly after the beginning of eternity, Nature began to put the uni-

verse in order. She at once began to make *distinctions* by getting her material together, and turning out worlds. It was the first step. Leaving other worlds to themselves, watch the progress of affairs at home. As soon as the first flurry is over, Nature settles down to the creation of differences. She puts the solid earth as a foundation, and piles the hot atmosphere above it; then she takes the water from the atmosphere, and we have air, earth, and water. With these she gets up some low forms of life. But, as she has only begun her work, she makes very little difference between the opposite ends of these forms. One end of a worm is so much like the other end that you may cut him in two, and one part putting on a tail and the other a head, you will in a short time have two very respectable worms. From these low forms, which carry as much life in one end as in the other, Nature goes on differentiating, till at last we find her getting up forms whose parts are so widely different that each has its own work to do, and one part cannot be substituted for another. A man losing any organ is imperfect; and many of his organs are such that the loss of one of them requires that he should go back into Nature's melting-pot, and be moulded over again into a new form of life—a Rhode Island pippin it may be, as good Roger Williams was. There is no record of any surgeon's having cut a man in two, and having made two men of the pieces. Nature is not content with multiplying species alone. She shows the same love for difference in varieties, and even in individuals, so that, as we are often told, there are no two peas exactly alike.

The utilitarian may ask: "But what is the need of all this variety? Why not have all peas alike?" This brings me to the important part of my essay; for, whimsical as some of my notions may appear to others, the conclusion to which I hope to bring my readers is to me a source of moral rest:

1. *Relation of Difference to Consciousness.*—How is it that we gain a knowledge of the external world whereby we become conscious intelligences? Simply by a perception of differences. What would follow were there no difference in color or shade? Go into a dark cellar with an extinguished candle to find a black cat that is not there. I know black is said to be no color, but it answers as an illustration. Your eyes are wider open than when above-ground in broad daylight, looking for a white cat that is there. Things being "all of a color," as common people remark when left in the dark, you are for the time as blind as the eyeless fish. Were white light put in the place of darkness, and each object to reflect it with absolute sameness, you would be just as unable to distinguish between objects, or between an object and its background. Were the black cat there eating a white rabbit, the cat having become white you could not tell where cat left off and rabbit began; neither could you tell where cat and rabbit ended and cellar-floor began. Everything would be of a piece.

You could make out nothing, though you had as many eyes as the "devil's-darning-needle" of our boyhood, and each eye were "in fine frenzy rolling." Call, now, that cellar the universe, and then see if you can show cause why we may not consider the sense of sight as practically gone, and all knowledge that comes through sight a sealed book; ay, more, that nothing would be left to give us a hint that such knowledge could possibly exist.

How is it that we receive knowledge through the ear? By noting the difference between sounds, and between sound and silence. But, if there were no difference, there could be no hearing. If we had always listened only to a single tone, varying neither in pitch nor force, we should not be aware of the sense of hearing. We should be as one born deaf. It is the difference of sounds that gives us through the ear knowledge and harmony.

As with the senses named, so with smell, taste, and touch. Did all substances affect these senses in exactly the same way, however acute those senses, we should not be aware of their existence. Ask any one what is the smell of pure air, and he will tell you, "No smell." But how do we know that to be the case? As it has always been in contact with our smelling-nerves, we cannot judge of its odor. A dweller in Jupiter coming to visit his mundane cousins might, when he struck our atmosphere, expand his nostrils, as one sniffs the air when he all at once smells something very nice, or he might turn up his Jovian nose, as though he smelt something very bad. It is an open question whether or not the atmosphere is odorless, or, as a layman would put it, whether it smells the same as empty space. Could an intelligent man be put under an exhausted receiver, get the smell of a perfect vacuum, and survive to tell about it, he might throw some light on the question.

To sum up my reasoning, it comes to this: Were the universe one of *sameness*, instead of the universe of *differences* that it is, we should be unconscious of any external world, or of our own existence, no matter though we were the best-born specimens of the scientific stirpiculturist. In fact, we should be an army of negations. I am aware there is something a little queer in the logic of this paragraph, but yet there is a great deal of sound logic in it after putting aside the "queer," which will, however, pass current with all except professional detectives.

2. *Relation to Knowledge.*—What is knowledge? Only a perception of differences. How is a knowledge of natural history, for instance, obtained? Simply by finding out differences. In this way child and philosopher classify the horse and the ox. Progress in knowledge is possible in proportion—1. To objective differences; and, 2. To perceptive ability. Take botany. It is easy to classify those plants which have obvious differences into genera; but, when we come to the classification of sub-species, the work is more difficult. A stu-

pid child can tell a piece of Boston brown-bread from a ginger-snap; but he cannot always tell whether his bread is spread with Orange County butter or oleomargarine.

Again, one man is color-blind, and in a knowledge of colors can make little progress. As an engineer, he would mistake a green for a red light; as a paint-mixer, he would be a failure; and, as a matcher of dress-goods, he would be little troubled by the sweet creatures to whom he belonged. Another man can distinguish not only the seven colors of the rainbow, but many shades of each. The progress of these two men in all knowledge resting upon color must differ widely. As in this, so in all departments of education: the man who is skillful in detecting differences holds the key to knowledge.

3. *Relation to Happiness.*—The wise and the good of all religions and the philosophers of every school are puzzled over what they term the evils of life. Assuming the Creator to be wise, good, and omnipotent, they wonder that he should allow these evils. They cannot understand the problem of pain and misery which meets them at every turn, and importunes for a solution. Why should there be any condition but happiness?

The philosophers best satisfied with the present order of things are those whom I shall name the *protoplasmics*. Denying the existence of a personal God, and falling back upon *protoplasm* as a substitute, they think that, taking into account the humble character of their protoplasmic god, he has done remarkably well. They are therefore very hopeful in their evolution theory, and in this respect have the advantage of their more orthodox brethren. They look upon creation with much the same feeling as that with which we look upon the first house built from cellar-drain to chimney-top by a self-made artisan. As a house pure and simple, it may be a failure, but as a self-made artisan's first attempt it is a wonderful success.

The great army of reformers, each in his way anxious to show himself the savior of the world, is but another proof of this widely-spread belief that the world is in a very bad fix.

That this problem of evil is as old as the race is shown in the golden-age idea, whether it comes up in the Hebrew religion with its Garden of Eden, or in the mythology of the Greeks and the Romans. The explanation is, perhaps, this: Man clothes his god with the highest attributes he finds in himself. These qualities he magnifies, and joins to them infinite power. Seeing that the world is evil, and, conscious of evil tendencies in himself, he finds his way out of the dilemma by asserting that there was once a golden age, the condition of the universe as it came from the hand of its Maker, and that all the evil that has crept into it has come from man alone. Thus he solves the problem of evil, and saves the character of his god. We must admit that the theory shows a good degree of charity, humility, and logic. It would be a still better scheme if in it there could be found

a place for charity toward the poor devil whom as yet neither charity nor logic can dispose of.

But there are other philosophers, among whom I count myself—I say it in all modesty, it runs in our family—who are not satisfied with any of these explanations, and very naturally ask: "Is the world a failure? Is it not a very good world? Is it not, in fact, as good as it can be? Were the united wisdom and goodness of the race supplemented with omnipotence and allowed to reconstruct the universe, could they improve upon the world as it is? Are these, that we name so, evils, or is it that we have failed to find out their character and use?" I purpose to answer these questions by applying to them the Law of Difference, which I conceive to be the panacea for the ills of life. Keep in mind that, as all knowledge comes to us as the result of the *different*, so do all emotions of pain or of pleasure. Every quality that is thinkable implies its opposite, or at least its different in degree. Happiness and misery are only relative terms. Absolute happiness cannot exist any more than a magnetic needle with only one pole. The sick man who rises for the first time for weeks from a bed of pain and is led out into the sunshine is very happy; while the strong man who has not known sickness for years is unhappy from some slight indisposition which scarcely interferes with his daily work. Why this difference? Simply from the contrast with the previous condition. He who would enjoy must suffer. The lives of some people pass so smoothly that we count them happy. They are simply in the possession of something whose value they have never known, hence it is to them worthless. If you want to know the full value of a clear conscience you must go through the hands of remorse. If you want to know the comfort of owning two shirts at a time, you must know the discomfort of owning no shirt at a time. Whence comes the pleasure we feel from our progress in knowledge? From the difference between the knowing and the not knowing of anything. Take the happiness that comes from social position in life. It arises from the fact that we are higher up than some one else. Bring all to the same level and it would be enough to make an angel weep to see how much happiness some people would lose. Many would be bankrupt. Take the tramps and vagabonds out of society, and the whole fabric would be cut down one story; for, to change the figure, they put one more round into the ladder—it matters not that it is at the bottom—and give the climber a chance to go one round higher. It is the length of the ladder that counts, no matter where the bottom is placed. What are wealth and poverty? Only relative terms. There is none so rich as the poor boy who has just received his first dollar after a week of hard work. We waste a great deal of pity on those who are born in the humbler ranks of life. It is my impression that, on the whole, it is better to be born poor, and work your way up to wealth and honor, than to have wealth and honor thrust upon you at birth, even though retained through life.

Nature has done much to create differences, and human egotism has come in to second the efforts of Nature, and supplement her work by getting up differences in our favor where no such thing in point of fact exists. B may be a fool, but thinks himself wiser than C, who is in truth far wiser than B. C thinks himself much wiser than he really is, and in comparing himself with B gets the full benefit of the real difference, with a large surplus from the inflation. Thus are both men made happy. Indeed, should you take each man's estimate of himself, you might, to find a fool, be obliged to do as Diogenes did to find an honest man. But, if you should take each man's opinion of other men's abilities, the fools would outnumber the wise men ten to one, that one being himself. Alas! what should we philosophers do were there no simple souls whereby to measure our colossal intellects? Thank God for wise men, but thank God for fools! Every fool as well as every knave has done a great deal for human happiness. Woe is the day when fools and knaves shall be no more! O stirpiculturist, stay thy hand, and leave us still a background to the great picture of life! And thank God for egotism, which enables us to make so much out of so little. It was not the philosopher that "Oh'd!" when the poet wrote:

> "Oh, wad some power the giftie gie us
> To see oursels as ithers see us!"

He was wiser who wrote—

> "Where ignorance is bliss 'tis folly to be wise."

It will be a black-letter day when we find ourselves out. Why not let us go on, each one thinking himself the biggest toad in the puddle, and being happy? Why not let us still have the difference in our favor, since it is so cheap a happiness, and withal so innocent?

Those who agree with me thus far may yet ask: "But is not the number as well as the degree of differences too great? Has not Nature rather overdone the thing when she gets up a hell-bender" (*vide* Webster and the Aquarium), "or gives us not only an Apollo whom we admire, but a leper whom we loathe?" Why, my dear sir, after all the orthodox animals were made—though I don't know where you would draw the line between the regulars and the irregulars—you and I both could find much pleasure in looking at a hell-bender, and he no doubt finds far more pleasure in being a hell-bender than in being nobody. However many forms we may have seen, we still want to see something different. Yes, but how about the miserable, suffering leper? How about these extremes of wretchedness? Something in the way of music may be got up from the eight simple tones of a simple octave. If you are to have music worth hearing, you must extend the scale through the octave above and the octave below; but, if you would have music with all its pathos, power, and sublimity, you must make use of all the octaves that are at the command of the

orchestra, from the low thunder of the big Boston organ to the shrillest wail of the Cremona fiddle. Nor do you want the major chords alone, you must have the minor tones, and discords, even. Can you spare the lowest octave from the big organ? If so, you bring the extremes an octave nearer, and so far restrict the range of the instrument, and by repeating the removal of the lowest notes you would at last find it impossible to play even the thinnest of tunes. So with human society. As you bring the extremes together, you take from life that which makes life worth having. The extremes in deep-water oyster society are very near each other, but each member of that society is only an oyster.

But how about the reformers? If things are all right as they are, why try to change them? My dear, short-sighted brother, the reformer can do no harm. He is a benefactor. He is only helping Nature out. He may cut off now and then a low note, but by adding two high ones he widens the range of the instrument. Society as a whole advances, but its extremes are probably farther apart than ever before. Moreover, if we take the world as a whole, we can still better understand the value of the reformer. Compare unreformed Africa, with its cannibalism and slow travel, with America, the land of the Grahamite and the home of the telegraph, and see if the various reformers have not made it a glorious thing to be a Caucasian! Every step in the moral world secured by the reformers makes greater the distance from the top to the bottom of the moral ladder. The day of the Inquisition and witch-burning has gone by; but the history of them still remains. We have only to read the old records, to find out what nice folks we are at the present day. I admit the conceit of some of these troublesome people, who believe they have a mission; but they are a necessary and important variety of the race. It is very plain that this world is the proper stamping-ground of the reformer.

Hence, variety is a necessity of life. The man that lives upon one kind of food only must deteriorate in body; the student who gives all his thought to one idea, will become crotchety; while the devotee to a single phase of religion will in time be a bigot, which is but another name for monomaniac. Sameness is the border-land of insanity. Have you ever been "possessed" by a whimsical idea, or a bit of poetry that would give you no let-up? If so, you can form some notion of the lunatic who was haunted with the idea that he carried in his stomach the twelve Apostles! There is many a man living a life of excessive toil or of idleness, of so fixed a routine that he is partially insane. It should be the aim of every man to so arrange his life as to bring into it a good degree of variety if he would secure physical, mental, and moral health. In this particular, division of labor often works mischief to the individual, however advantageous it may be to the community. Imagine the stupidity that must creep over

the mind of a man who spends year after year pointing pins! It may be well to inquire as to whether or not the social and business framework of society is not doing much to reduce some of its members to a state little better than monomania.

To enforce the lesson taught by the Law of Differences we will pass by a million years, while I give the reader a picture of the reconstructed universe. It had been reformed to that degree that the wildest dream of the idealist had been realized. Desiring to have one more look at the old homestead, I came back from spirit-land, was "materialized," and once more walked the solid earth as was my wont a million years before. I need not say I was not quite up to the times. The first thing I noticed was that my physical geography was all at fault. There were no burning sands, no icy wastes, no earthquake, no tornado, no flood, no drought. The whole earth from pole to pole was on the golden-age pattern. In this respect, desire was satisfied. For centuries no one had been heard to complain of any imperfection. All was lovely. To me, with a recollection of what I had suffered in my youth in cold and barren New England—ten in the family, and all big eaters—the change was delightful. But what was my surprise not to find a single soul to share my pleasure! When I talked to those I met of their beautiful world, I spoke in an unknown tongue. I might as well have tried to convince Jones, the druggist, that pure air was as fragrant as the odors which blew from Araby the blest, or any other Araby. Jones would have told me, "I have had air in my nose for fifty years, and, if there is any smell in it, don't you suppose I should have found it out in that time?" They were as stolid as marble, and as unenthusiastic as a proper woman who never felt the slightest twinge of hope, fear, love, hate, or anything else, except propriety. "It is strange," said I, "that no one understands what I feel. . . . Well," I thought, "they have never known anything *different*, and as a result they do not know this."

I was no less agreeably surprised at the men and women whom I found peopling the globe. The stirpiculturist had finished his work and gone home. There was not a physical deformity of any kind among the millions that walked the earth. All were brought up to the highest type of physical beauty. There was not a woman I met with whom I did not instantly fall in love, though it was like Caliban falling in love with the houris. Every man was an Apollo, and every woman a Venus. But I was surprised to see them so blind to each other's charms. The men were the slowest of slow lovers; the women as responsive as lay-figures. "Ah! well," I sighed, "they never saw in man or in woman anything but beauty, and now they see not that." It seemed that a sight of me, which some of them could not endure without a shudder, had begun to awaken in them a new sense of which the stirpiculturist had robbed them—a sense of the beautiful.

Being by nature benevolent, and inheriting a missionary spirit, it did me good to think that I was serving so useful a purpose, and starting a mission for the conversion of these heathen in æsthetics. With a force that almost took away my breath, it came to me that we owe a great debt to the deformed, the hideous, and the wicked; that those, the morally hideous, whom society hunts down as its worst enemies, spend their lives in serving the very class that seeks to destroy them.

Then, too, the goodness and holiness of the reconstructed world! There were met with only those with whom, having been so well generated for a thousand years, regeneration was impossible. A long line of physical, mental, and moral saints were the ancestors of the race. "What a perfect heaven!" I said to them. But I found upon their faces only a gingerbread-rabbit expression. Such words as heaven and hell conveyed to them no more idea than green or red conveys to a blind man. I was in despair at such a lack of appreciation. Here was practically the heaven upon earth which the race had worked for, prayed for, agonized for; and, now that it had come, no one seemed to enjoy it, or even to know of its existence. It is truly a misfortune to be born in and always to live in heaven. The eternal Law of Differences holds us fast. Hell is a necessity, which must be as deep as heaven is high. The world was better as it was before the reconstructers got hold of it. Give us back the iron age! All is not gold that glitters. My prayer was answered, and I found myself once more in this world of sin and holiness, joy and sorrow—in a word, back in this world of differences.

MAN AND THE GLACIAL PERIOD.

By THOMAS BELT, F. G. S.

CONCERNING the Glacial period, geologists hold the most varied opinions, both with regard to its origin and to the mode of action of the ice. Thus at the very threshold of the geological record we tread on uncertain ground, and every guide points to a different path. The relation that palæolithic man bore to the great ice age might seem to be of easier solution; but even this question is unsettled, and a subject of controversy and doubt. Prof. Prestwich is believed by many to have proved that palæolithic man was post-glacial. Messrs. Croll and Geikie urge that there were two or more glacial periods in post-tertiary times, and that he flourished in a mild interglacial period. I, on the contrary, have been gradually forced to conclude that, in the British Isles, all the remains in caves and valley-gravels referred to palæolithic man are preglacial, in the sense that they are

of earlier date than the glaciation of the districts in which they are found.

I propose to state briefly some of the general arguments that have influenced my opinion, and then to deal with the special question of the age of the deposits at Hoxne, which the advocates of the post-glacial theory put forward as being undoubtedly in their favor.

Let us first take into consideration the age of the beds containing the remains of the mammoth, the woolly rhinoceros, and their companions, with which the palæolithic implements are so often found. Wherever, in Europe, the relation of these beds to the bowlder-clay can be clearly seen, they are of distinctly older age. Thus, in Russia, Sir Roderick I. Murchison has recorded the discovery of the bones of the mammoth and woolly rhinoceros, near Moscow, in reddish clay covered with erratic blocks, on the plains thirteen miles distant from the river.[1] And if we follow the northern drift southward from Moscow, as I have done, we find it gradually changes from clay with bowlders to the clay without bowlders that covers the southern plains. Around the sea of Azov, cliffs of this glacial clay, one hundred feet high, can be followed continuously for miles, and its junction below with the older beds is sharply defined. It rests on a fresh-water deposit containing shells of species of *Unio*, *Cyclas*, and *Paludina*, and at this horizon fragments of the tusks and bones of the mammoth are abundant, and are always undoubtedly older than the glacial clay. In a similar position the same remains have been found at Odessa and other places in the south of Russia.

Nor has the theory of the post-glacial age of the remains of the mammoth remained unchallenged by eminent geologists in England. Prof. Phillips[2] and Mr. Godwin Austen[3] long ago recorded their conviction that they belonged to an earlier period than the deposition of the bowlder-clay, and that when they occur in newer beds they have been derived from an older formation. The remains are so plentiful in the caves of the north of England that it is certain that the mammoth and rhinoceros were abundant. Yet nowhere in the glaciated parts of the country have the bones been found excepting where preserved from the action of the ice in caverns and fissures.

Thus, in tracing the limits of the northern ice on the eastern side of England, I have found that Durham and Northumberland were probably completely overflowed by it, excepting the upper parts of the Cheviots, as pointed out to me by Mr. Richard Howse. The ice streamed through from the west, around the southern and northern flanks of the Cheviots, down the valleys of the Tyne and the Tweed, and when approaching the eastern coast was deflected to the south by the great mass of ice that occupied and was flowing down the bed of

[1] "Geology of Russia in Europe," p. 650.
[2] "Geology of Yorkshire," 1829, vol. i., pp. 18, 52.
[3] "British Association Reports," 1863, p. 68.

the German Ocean. In Yorkshire the ice from the west was held back by the Pennine Chain, and did not coalesce with the German Ocean glacier, but stopped short, somewhere about an irregular line drawn from Keighley, northeastward to near the mouth of the Tees. The German Ocean glacier only, as it were, grazed the high land bordering the coast until it reached the northern shores of Norfolk that stood out across its track. A large portion of Yorkshire was thus never glaciated by land-ice, and in this area remains of the great extinct mammals have been found in and below the lowland gravels, as at Leeds and Market Weighton; but when we pass northwestward into the country where the striæ on the rock-surfaces bear witness to the passage of land-ice, no such remains are found, excepting in caverns and fissures of the old rocks.

The northwestern side of England is much more glaciated than the northeastern, and the mammalian remains have only been found where preserved in caves. The ice filling the Irish Sea reached to a height of 2,000 feet on the western flank of the Pennine Chain. Probably reënforced from the westward it continued, in scarcely decreasing thickness, across the whole of Lancashire and Cheshire, and passed over into the drainage area of the Severn, down which valley it appears to have flowed for some distance. As soon as we get beyond its influence we again meet with mammalian remains in the lowland gravels, and in most of the southern valleys they are abundant.

If the mammoth and its associates roamed as far as the north of England, and even into Scotland, after the Glacial period, their remains ought to be found in the valley-gravels of the glaciated districts. They are, however, absent; and if we should be led to infer from this that they lived before the glaciation of the country, and accept the conclusion of Prof. Phillips and Mr. Godwin Austen that the mammoth and the woolly rhinoceros lived before and not after the Glacial period in Great Britain, we can scarcely refrain from going further than these geologists and concluding that the makers of the palæolithic implements were also preglacial. For no geological inference seems based upon sounder evidence than that palæolithic man was contemporaneous with the mammoth and its associates. The implements of the one and the bones of the others are found together in the same stratum of the cave-earth, and in all the numerous caverns that have been searched in England and Wales there is no record of palæolithic implements being found at a higher horizon; when flint weapons do so occur they are invariably of the neolithic type. If geological evidence of contemporaneity is of any value, the occupation of the caves by palæolithic man ceased at the same time as the great mammals disappeared.

Let us look at the question from another point of view. In the south of England the remains of the mammoth are abundant in the

valley-gravels. They are found mixed through them, or more commonly at their base. Palæolithic implements are found in the same position, though usually in gravel higher up on the slopes of the valleys. When found in the gravel, the bones are broken and worn, and the flint implements have their angles rounded more or less as if by rolling. When, as has happened in a few cases, the bones and implements have been found below the gravels, they have been uninjured and unworn. Mr. Godwin Austen noticed the occurrence of bones of the mammoth in an old forest-bed beneath the valley-gravels, at Peasemarsh, in Surrey, uninjured and lying together, while in the overlying gravel the teeth of the mammoth were found singly and rolled.[1] And Colonel Lane Fox has recorded the discovery of flint implements at Acton in seams of white sand, nine feet from the surface, beneath deposits of gravel and brick-earth.[2] Their edges were as sharp as if just flaked off a core of flint; while those found in the gravel, on the contrary, have their edges worn and rounded just like those of the subangular pebbles of which the gravel is principally composed.

The position and the state of preservation of the bones and implements are such as might be expected if they had been deposited on an old land-surface before the outspread of the gravels, when the configuration of the country was much the same as now; and I have suggested that the occurrence of the implements, generally higher up the slopes of the valleys than the mammalian remains, is due to palæolithic man having frequented more elevated and drier localities than the great mammals. I have urged that the outspread of the gravels was due, as formerly supposed by Sedgewick, De la Beche, and Murchison, to the action of a great flood or debacle. I have advanced the theory that that debacle was caused by the breaking away of a barrier of ice that blocked up the English Channel, and with it all the drainage of Northern Europe, causing an immense lake of fresh or brackish water that was thus suddenly and tumultuously discharged.[3]

This great flood occurred, according to my theory, before the culmination of the Glacial period, and was primarily due to ice filling the bed of the North Atlantic as far south on the European side as latitude 49°. If the gravels in and below which the rude flint implements and the remains of the extinct mammals are found, were thus spread out, it follows that they were preglacial in the sense that they lived before the principal glaciation of the country.

We have seen that, in the north, such an excellent geologist as the late Prof. Phillips had arrived at this conclusion with regard to the age of the mammoth, the woolly rhinoceros, and the hippopota-

[1] *Quarterly Journal of the Geological Society*, vol. vii., p. 288.

[2] Ibid., vol. xxviii., p. 456.

[3] *Quarterly Journal of Science*, April, 1875. *Quarterly Journal of the Geological Society*, vol. xxxii., p. 84.

mus; and, in the south, Mr. Godwin Austen, from a study of the same remains in the valley-gravels. Direct evidence of great value has been added by Mr. Tiddiman in his reports on the exploration of the Victoria Cave, at Settle. He has shown that the cave-deposits lie beneath glacial clay, and, among the other remains, a human fibula has been found.[1] In the Cefn Cave, in Denbighshire, Mr. Mackintosh has also determined that the mammalian remains lie in and below a glacial clay.[2]

All the lines of inquiry thus far pursued in this paper point to the preglacial age of the remains in question, and some of the facts are directly opposed to the post-glacial theory. How, then, is it that the great majority of geologists write as if it had been clearly proved that palæolithic man was of post-glacial age? Principally because it is believed that Prof. Prestwich has proved that at Hoxne, in Suffolk, the implements and bones are found in deposits distinctly overlying bowlder-clay. This is spoken of as if it were a truism in most general treatises on geology;[3] and both in Europe and America the presumption is appealed to as being conclusive with regard to the age of the remains. The general opinion held is concisely given in the statement by Mr. John Evans in his presidential address to the Geological Society last year, that, at Hoxne, "the implement-bearing beds repose in a trough cut out in the upper glacial bowlder-clay, which itself rests on middle glacial sands and gravels."[4]

This opinion of the age of the Hoxne deposits is founded on the elaborate memoir by Prof. Prestwich, published in the "Philosophical Transactions of the Royal Society," for 1860. In this treatise the author gives a diagram showing the deposits in question lying in a trough cut out in the bowlder-clay. Though this section is confessedly only theoretical, it was accepted by Sir Charles Lyell and others as an actual one, and afterward the author himself wrote as if he had proved his theory to be true,[5] which he may well be excused for having done, when it had been accepted by so many eminent geologists.

The writings of Prof. Prestwich are admirable in this, as in other respects, that, although he indulges in wide-reaching theories, he invariably gives the evidence on which they are founded. Thus, in the memoir in question, in addition to the theoretical diagram he gives another, showing the actual facts observed, and also careful details of the various sections observed by him. It is, therefore, possible to check his theory by his facts, and in the present paper I shall do so,

[1] *Nature*, vol. ix., p. 14. "British Association Reports," for 1873, 1874, 1875.

[2] *Quarterly Journal of the Geological Society*, vol. xxxii., p. 91.

[3] Sir Charles Lyell, "Antiquity of Man," p. 166. J. Geikie, "Great Ice Age," p. 474. J. Croll, "Climate and Time," p. 241. W. Boyd Dawkins, "Cave-Hunting," p. 410. Jukes's "Students' Manual of Geology," p. 736.

[4] *Quarterly Journal of the Geological Society*, vol. xxxi., p. 74.

[5] "Philosophical Transactions," 1864, p. 253.

and also give the results of my own examination of the Hoxne district.

Mr. John Frere, so long ago as the first year of the present century, communicated to the Society of Antiquaries a "Account of Flint Weapons discovered at Hoxne, in Suffolk."[1] He stated that they were found in great numbers in a bed of gravel, which was overlaid by one foot of sand with shells, and containing the jawbone and teeth of an enormous animal; the sand being again covered by seven and a half feet of brick-clay. Mr. Frere noticed that the strata lay horizontally, and had been denuded to form the present valley, and therefore concluded that they belonged to a period when the configuration of the surface was different from what it is now, and he considered that their antiquity was possibly "even beyond that of the present world." The manner in which the flint implements lay, and their great abundance, led Mr. Frere to conclude that a manufactory of them had been carried on at the place where he found them.

The discovery does not appear to have excited any attention at the time, and for more than half a century remained unnoticed. In 1859, when the discovery of flint implements in the valley of the Somme, in France, in association with the remains of the mammoth and other extinct mammals, had at last aroused the attention of geologists, Mr. Frere's memoir was brought by Mr. John Evans before the notice of Mr. Prestwich, who had just returned from Amiens. He soon after visited Hoxne, and carefully examined into the facts of the case. He found that the bed of brick-clay was still being worked, and that flint implements were occasionally, though rarely, turned up; and on a subsequent visit with Mr. Evans they succeeded in disinterring one themselves.

The valleys of the Waveney and its tributaries are bounded by low hills of gravel and bowlder-clay. The bed-rock is not seen in any of the sections exposed, but it is supposed to be chalk. The gravels and sands (the middle glacial sands and gravels of Mr. Searles Wood, Jr.) are exposed in many gravel-pits on both sides of the Waveney. They are sometimes capped by the upper bowlder-clay; at others, by a more sandy bed with stones (the "trail" of Mr. Fisher), which in some of the sections graduates into the upper bowlder-clay, of which I believe it to be the modified representative. One of the deepest sections on the north bank of the Waveney is near the road from Diss to Harleston, at Billingford, where the series of beds shown in Fig. 1 are exposed.

Mr. Fisher some time ago called attention to the great importance of the upper bed, or "trail," in the study of the glacial beds,[2] but it has not yet received the notice it deserves. It is the most persistent of all the beds in the southeastern counties, and can be traced, in al-

[1] "Archæologia," 1800, vol. xiii., p. 206.

[2] *Quarterly Journal of the Geological Society*, vol. xxii., p. 553.

most every section, from Norfolk into Surrey. It is everywhere seen in the Thames Valley lying on the top of the lowland gravels, and is shown in great perfection in the long section now (March, 1876) exposed between Acton and Hanwell, on the Great Western Railway.

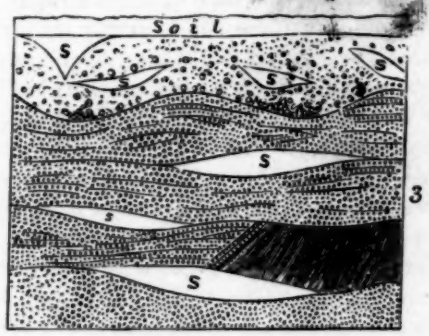

Fig. 1.—Scale twelve feet to one inch. 1. Sandy clay, or "trail," with patches of sand (*S*) and scattered flints, mostly in nests, at the irregular base of the deposit. 3. Sands and gravel, false-bedded with lenticular beds of sand (*S*), and in the lowest seams rounded pebbles of chalk.

It generally, if not always, rests upon an irregular surface of the beds below it, and contains stones derived from some other source.

On the south side of the Waveney, at Syleham, there are good sections on both sides of the turnpike, and these exhibit similar false-bedded sands and gravels, which are, however, covered by the upper bowlder-clay instead of by "trail." Fig. 2 shows a section exposed

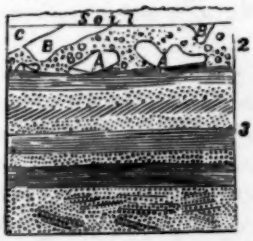

Fig. 2.—Brown bowlder-clay, with many whole flints, and with angular patches of red sand (*B*), marly clay with small stones (*A*), and red bowlder-clay (*C*). 3. Sands and subangular flint, gravel with rounded pebble of quartz, and (in the lowest seams) of chalk.

on the south side of the turnpike. A little farther west, on the north side of the turnpike, is another gravel-pit, showing a similar succession, but with the beds of sand and gravel strongly false-bedded. In all these sections small pebbles of chalk are very abundant in the lowest beds. The most remarkable feature in the upper bowlder-clay is the numerous angular patches of material quite different from the matrix of brown clay. The angular patches of red sand are very peculiar and difficult to explain.

In a large gravel-pit a little north of Oakley Church there is a long

section exposed, and in it the upper bowlder-clay, similar to that shown in Fig. 2, at one end of the pit, gradually changes into a sandy loam with stones and angular patches of sand, not to be distinguished from the deposit named "trail" in Fig. 1.

At Hoxne itself, on the east side of Gold Brook, there is a gravel-pit showing seams of gravel and sand exactly similar to that at Syleham, but surmounted by sandy "trail" instead of by bowlder-clay. The gravel is not to be distinguished from the other, being composed like it of subangular flint-pebbles with rounded ones of quartz and quartzite, and with many small pebbles of chalk in the lowest seams. Notwithstanding this great similarity, Mr. Prestwich considers the beds at Hoxne to have been formed by river-action in post-glacial times; while those at Syleham, being capped by bowlder-clay, he of necessity classifies as middle glacial. Yet I could find no difference whatever in their appearance or composition. In both the pebbles are mostly small and subangular, with some rounded ones of quartz and quartzite. Both contain many small pebbles of chalk in their lowest seams, and both are false-bedded. That one is covered with bowlder-clay and the other by sandy "trail" does not suffice to prove them of different age, for at the Oakley gravel-pit we can trace the same gravels from one end, where the bowlder-clay overlies them, to the other, where the "trail" does so. The middle sands and gravels are generally supposed by geologists to be marine, and it is incredible that deposits due to such different agencies as that of the waves of the ocean beating on a beach and that of a flooded river should be absolutely identical in appearance and composition. But nowhere is either the ocean or any river known to be forming deposits of subangular pebbles, excepting where they are cutting into preëxisting beds of the middle glacial series. Both in sea and in river beaches the pebbles are smoothly rounded, and not, as in the gravels under consideration, broken and subangular. Even when we find in the latter rounded pebbles of tertiary age there is often a piece chipped out of them as if they had been dashed violently together. I have had a large number of the pebbles from the gravel at Ealing counted, and find that over eighty per cent. are broken or subangular. I ask where, in the whole world, is such a deposit being formed by existing agencies? Surely, if ordinary floods would produce them, they have had plenty of opportunities of doing so during the past pluvial year; yet where, on the banks of any of our rivers, have the great floods left deposits even approaching in character to those that geologists confidently ascribe to river-action? That they were caused by a great flood I fully believe, though not by that of any river, but by one that swept over the whole country, driving a huge mass of gravel and sand, and leaving them mantling both hills and valleys, holding or covering up the remains of palæolithic man and the great mammals that had lived before the waters were pent up by the Atlantic glacier.

A little above Hoxne, on the left side of the stream called the Gold Brook, is the Hoxne clay-pit. The clay is excavated along the slope of the shallow valley through which the brook runs. The road to Eye skirts the hill-side, having to the west the park of Sir Edward Kerrison; and to the east, between it and the stream, a narrow strip

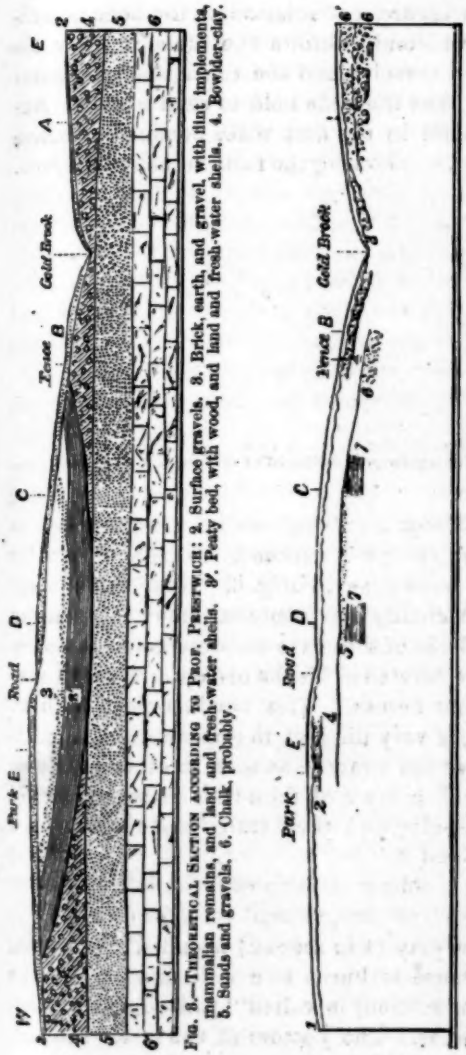

FIG. 3.—THEORETICAL SECTION ACCORDING TO PROF. PRESTWICH: 2. Surface gravels. 3. Brick, earth, and gravel, with flint implements, mammalian remains, and land and fresh-water shells. 3'. Peaty bed, with wood, and land and fresh-water shells. 4. Bowlder-clay. 5. Sands and gravels. 6. Chalk, probably.

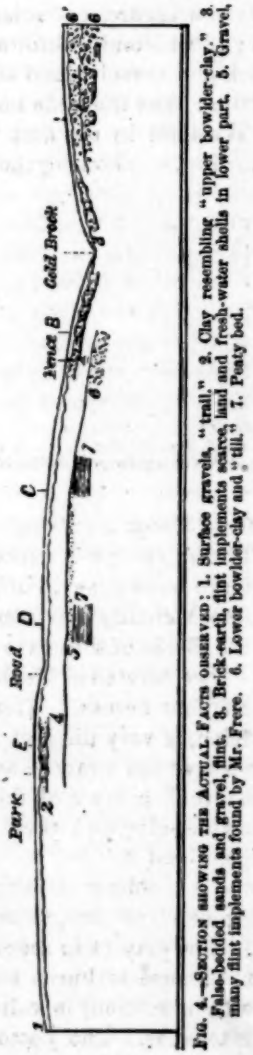

FIG. 4.—SECTION SHOWING THE ACTUAL FACTS OBSERVED: 1. Surface gravels, "trail." 2. Clay resembling "upper bowlder-clay." 3. False-bedded sands and gravel, flint. 3. Brick-earth, flint implements scarce, land and fresh-water shells in lower part. 5. Gravel, many flint implements found by Mr. Frere. 6. Lower bowlder-clay and "till." 7. Peaty bed.

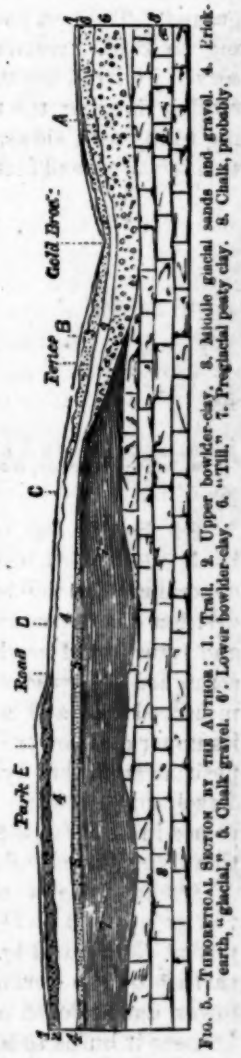

FIG. 5.—THEORETICAL SECTION BY THE AUTHOR: 1. Trail. 2. Upper bowlder-clay. 3. Middle glacial sands and gravel. 4. Brick-earth, "glacial." 5. Chalk gravel. 6'. Lower bowlder-clay. 6. "Till." 7. Preglacial peaty clay. 8. Chalk, probably.

of land from which the clay has been dug. The old workers had commenced near the village of Hoxne, and as they gradually exhausted the clay up to the road they moved farther southward, and the point at which it is now excavated is probably at least a quarter of a

mile distant from that where Mr. Frere made his discoveries in 1800. The pit has now been worked up to some farm-buildings that interfere with its progress southward, and to get clay they have now crossed the road into the park, and thus made a most important addition to the section laid open.

I have in the accompanying plate given three sections of the ground. The first shows the theoretical relation of the beds according to Prof. Prestwich; the second exhibits the facts actually observed by Prof. Prestwich and myself; and the third is a theoretical section showing the relation that the beds hold to each other according to my own views. We shall in the first place confine our attention to the second section (Fig. 4), showing the facts actually observed.

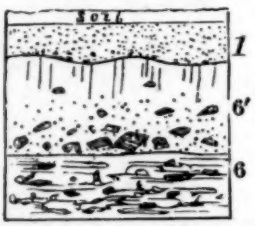

FIG. 6.—1. "Trail," three feet. 6' and 6. Bowlder-clay, chalky in upper part: a slight line of division between it and the lower part, which is principally composed of crushed Kimmeridge clay with pieces of chalk.

On the east side of Gold Brook a cutting has been made into the bank, and a thick bed of bowlder-clay is exposed. At the point *A* in general section the beds are shown, as in Fig. 6. Near the line of division the upper and more chalky clay contains many large flints and transported bowlders. Some of these are smoothed, and strongly scratched and grooved. Two scratched blocks of septaria that I saw measured one and a half foot across. This bowlder-clay, both in its upper and lower division, is very distinct in appearance and composition from that lying above the gravels, as seen in other sections. Lower down toward the brook a seam of false-bedded sandy gravel comes in between the bowlder-clay and the "trail," and represents, I think, the gravels of Figs. 1 and 2.

Crossing the brook and ascending the opposite slope, we have, at the points *C* and *D* of general section, typical sections of the clay-pit, as shown in Fig. 7. The clay (4 in section) is called "red-brick earth" by the workmen, because it burns to a red color; while the lower, dark-colored clay (7 in section) is called "white-brick earth," because it burns to a white color. The bottom of the latter bed has not been reached, although Prof. Prestwich had a boring put down into it to a depth of seventeen feet. It is full of vegetable matter, and I found numerous pieces of wood in it. The men pointed out to me the gravel-seams (5 in section), as the horizon at which flint implements had been found; but, shortly before Prof. Prestwich visited the

pit, two specimens had been taken from the lower part of the clay (4 in section). There can be little doubt, however, that they were found by Mr. Frere in the gravel below the "red-brick earth," as he says that "they lay in great numbers at the depth of about twelve feet in

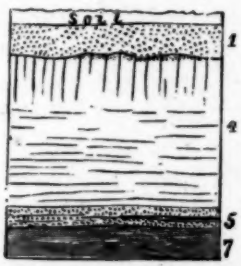

Fig. 7.—1. Sandy "trail" with flint-pebbles. 4. Yellowish-brown clay, unstratified at top and graduating downward into obscurely stratified chalky clay—ten feet. 5. Two thin bands of small chalky gravel, separated by eight inches of loam. 7. Dark calcareous clay, with fragments of wood and other vegetation.

a stratified soil, which was dug into for the purpose of raising clay for bricks. Under a foot and a half of vegetable earth was clay seven and a half feet thick, and beneath this one foot of sand with shells, and under this two feet of gravel, in which the shaped flints were found generally at the rate of five or six in a square yard. The manner in which the flint implements lay would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit. Their numbers were so great that the man who carried on the brickwork told me that, before he was aware of their being objects of curiosity, he had emptied baskets full of them into the ruts of the adjoining road."

As I have already mentioned, the place at which the clay is now excavated is some distance from that where Mr. Frere found the implements, and they are now very seldom met with—so seldom, that none of the men working at the clay-pit when I was there had ever seen one.

To the west of the road, in the pit that has been opened in Sir Edward Kerrison's park, a section of the beds has been exposed at the point marked *E* in general section, as shown in Fig. 8. The most remarkable feature in the section is the occurrence of the upper clay (2 in section), containing angular patches of red sand, like that seen in the "upper bowlder-clay" of other parts of the district. I cannot help thinking that, if this section had been open when Prof. Prestwich examined the deposits, he would have been led to modify his opinion respecting the relation of the deposits to the Glacial period. I myself believe this clay to be the upper bowlder-clay, and the sand with pebbles below it to be the "middle glacial sands and gravels."

To trace the "red-brick earth" (4 in section) down toward the lower bowlder-clay, I set some men to work, and had a shaft sunk—at

the point marked *B* in general section—to a depth of seventeen feet from the top of the surface-soil, and obtained the section shown in Fig. 9. The most noticeable feature in this section is the thickening out of the false-bedded sands and gravels, their resemblance to the middle glacial series, and the absence of the "white-brick earth" (7 in section). In a pit a little east of this, Prof. Prestwich and Mr. John Evans found a flint implement in the gravel-bed (3 in section).

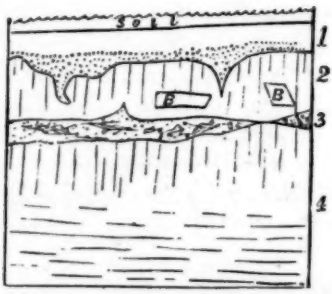

FIG. 8.—1. Sandy "trail" with flints graduating downward into sand, filling pipes in clay below. 2. Unstratified yellow clay, containing isolated angular patches of reddish sand. 3. Whitish sand with a few scattered pebbles, sometimes changing into reddish sand, like that of the patches in the clay above. 4. Yellowish-brown clay ("red-brick earth"), unstratified at top and graduating downward into laminated calcareous clay.

I have now given all the facts at present known respecting the relation of these beds to the Glacial period, and I proceed to the consideration of Prof. Prestwich's theoretical views, as shown in the general section (Fig. 3). In the first place, Prof. Prestwich identifies the bowlder-clay seen in the pit on the east side of the brook as the upper bowlder-clay. As I have already mentioned, it in no respect resembles the clay seen in other sections above the false-bedded sands and gravel, and the existence of the middle glacial beds below this particular deposit is entirely theoretical. Prof. Prestwich makes these sands and gravel to pass under the brick-clays; and I feel confident it will astonish many of those who appeal to this section, as proof of the post-glacial age of palæolithic man, to learn that they have never been seen in this position, and that their presence is an assumption only. The "red-brick earth" ought, according to Prof. Prestwich's views, to thin out eastward, and the dark clays or "red-brick earth" to crop up to the surface from underneath it. Instead of this, as shown in Fig. 8, at the point *B* in general section, the "red-brick earth" follows down the slope of the hill, and is not underlaid at all at that point by the dark clays. I do not, however, attach much importance to this, as the "red-brick earth" might mantle the hill, overlapping the edge of the dark clays, and yet Prof. Prestwich's general idea of the relation of the latter to the glacial beds be correct. What I do wish to point out is, that that relation is not proved by any of the facts known, and that an entirely different interpretation

is not only possible, but more probable. That other interpretation I have indicated in the general section (Fig. 5), in which all the facts observed are incorporated. I consider that the dark clay with vegetable remains and bones of the large extinct mammals is preglacial, in the sense that it is older than any of the glacial beds of the district. The gravel below the "red-brick earth," in which Mr. Frere found the flint implements, is probably of the same age, or that of the overlying gravel (5 in Figs. 4 and 5). That the implements, and also fragments of bones and wood, should be occasionally found in the overlying deposits, is what might be expected, as they were in great measure formed by the denudation of the older ones. The "red-brick earth" (4 in section) is, I believe, a true glacial clay, belonging to the latter part of the first European lake. It is a noticeable fact that, all over Northern Europe, the glacial clays burn to a red color—a point not without significance with regard to the red beds of Per-

FIG. 9.—1. Sandy "trail" with flints—three feet. 3. False-bedded sand and subangular gravel—four feet six inches. 4. "Red-brick earth," yellow and unstratified at top, graduating downward into gray, laminated, calcareous clay; shells of *Bithinia tentaculata* and *Limnea palustris* abundant at its base, where there is about six inches of sandy clay—four feet six inches. 6. Clay similar at top to the lower part of the "red-brick earth," but with more chalk-grains, gradually more chalky downward, and with stones like the upper portion of the lower bowlder-clay at point *A* in general section.

mian or Triassic age. The false-bedded sands and gravels (3 in Figs. 4 and 5) belong, I think, to the middle glacial series, and the clay (2 in Figs. 4 and 5) is, I think, the upper bowlder-clay. These views are only theoretical, but I claim that they are based upon as sound a foundation, and are as much in accordance with the facts of the case, as those generally received.

Another interpretation is tenable, namely, that the lower bowlder-clay underlies the brick-clays, and that the upper bowlder-clay overlies them, while they themselves belong to a warm interglacial period, as held by Messrs. Croll and Geikie. I do not agree with this opinion, as I can nowhere find any evidence of a warm interglacial period, and am unwilling to believe that there were more post-tertiary glacial periods than one, when one will explain all the phenomena; but if it were to turn out that the lower bowlder-clay does exist beneath the brick-clays at Hoxne, it would be one of the strongest facts in its favor yet brought forward.

I now come to the real point and object of this paper. We have in England, at Hoxne, one of the finest opportunities known to exist anywhere in Europe of determining the true relation that the beds containing remains of palæolithic man and the great extinct Mammalia bear to the Glacial period; yet we have been content for more than a dozen years to allow the age of the beds that underlie these deposits to remain a conjecture, and to accept a theory instead of ascertaining what are the true facts of the case. The geological world has been taught to believe that a question was settled that is not settled. We do know the age of the Hoxne deposits: they may, as held by Prof. Prestwich, be post-glacial; or they may, as held by Messrs. Croll and Geikie, be interglacial; or, lastly, they may, as I hold, be preglacial.

It is not creditable that this uncertainty should remain when it can easily be cleared up. A few shafts or bore-holes put down would soon determine whether or not glacial beds underlie the dark clays of the brick-pit, or sands and gravel underlie the bowlder-clay on the other side of the brook. Excavations should also be made around the spot where Mr. Frere made his discoveries, to ascertain the exact position in which the flint implements were found so abundantly. I feel satisfied that, if Sir Edward Kerrison, to whom the property belongs, were applied to by any of our learned societies, he would willingly allow the necessary excavations to be made. Probably the expenditure of two hundred pounds would be amply sufficient, and I submit that it is a work that should be undertaken by the Royal Society or the British Association, who make grants for scientific inquiry.—*Quarterly Journal of Science.*

EFFECTS OF STUDY ON THE EYESIGHT.[1]

By WARD McLEAN.

A POPULAR error has long existed as to the real character of short-sightedness; and even medical men have to some extent participated in it. It is *not* an indication of strength of vision. It is *a disease*, always inconvenient, and sometimes dangerous. Its char-

[1] The circumstance that one of the children of the writer is temporarily withdrawn from school because of injury to his sight contracted in study, has led him to look into this subject, and this paper is the result. The startling extent, the rapid increase, and the serious character, of these visual defects in our schools, and the fact that the greater part of them originated there, and might have been prevented, should awaken universal interest, that the proper remedies may be applied to arrest the evil as speedily and effectually as possible.

The writer having submitted this paper to Dr. David Webster, of this city, takes this occasion to acknowledge, with great pleasure, his obligation to him for important suggestions.

acter, cause, and progress, have enlisted the earnest attention of the most eminent oculists, especially during the last decade. The movement received its first impulse from a suggestion of Prof. Donders, made in 1864. It originated, therefore, at the very fountain-head of influence and authority in ophthalmology; for Donders was one of the three men who led in what is now styled "The Great Reformation," wrought some twenty-five years ago, in the treatment of defects and diseases of the eye. To illustrate the character of this change, Dr. Agnew, of New York, in his analysis of 1,065 cases of asthenopia (weak sight), thus describes the standard treatment for this disease only thirty years ago:

"Blisters, mercury, low diet, tartar-emetic, bloodletting, applications of irritating alkaloids, such as veratria, to the circum-ocular parts, and setons, were freely employed. Sometimes the sufferers were so subdued or silenced by the treatment that they ceased to complain of their eyes, preferring to endure the ills they had, rather than to endure those which the attempts to relieve their asthenopia led them to. So common was this treatment," he continues, "that more than one clever irregular practitioner made his fame and fortune in putting the exhausted subjects of it under hygienic rules, and giving them new life and hope by a generous dietary and free out-of-door life; thus showing how so-called quackery is often the natural offspring of our ignorance."

The suggestion of Prof. Donders is found in his work, "Accommodation and Refraction of the Eye," and is as follows:

"It would be of great importance to possess accurate statistics of the near-sight and far-sight occurring at a given time in a particular category of men, especially, for example, among the students of a university, in order to be able to compare them with the results of repeated investigations at subsequent periods. If it were thus found—and I can scarcely doubt that it would be so—that near-sight is progressive in cultivated society, this would be a very serious phenomenon, and we should earnestly think of means of arresting this progression. Not only is the near-sighted person not in a condition to discharge all civil duties, not only is he limited in the choice of his position in society, but in the higher degrees near-sight leads to disturbance of the power of vision, and threatens its subject with incurable blindness."

About two years after this, Dr. Cohn, of Breslau, published the startling result of his investigations, which had taken the form of an inquiry into the effects of study on the eyesight. Similar investigations followed in various parts of Europe.

A like movement is progressing in this country, which was initiated by Dr. Cornelius R. Agnew, of New York. Under his auspices, examinations have been made in New York, Brooklyn, and Cincinnati. Dr. Edward G. Loring, Jr., and Dr. Peter A. Callan, of New York; Dr. Lucien Howe, of Buffalo; and Dr. Hasket Derby, of Boston, have reported investigations in the same direction.

In some of these investigations the suggestion of Donders has been literally followed; while in most of them the effect of several

successive examinations of "a particular category of men" has been sought to be realized by one examination of several classes of students in the various stages of advancement in study.

In the thirty-three schools of Breslau, including its university, Dr. Cohn examined 10,060 pupils of all grades, and found that 1,004 of the number, distributed among all the schools, were near-sighted; and that only twenty-eight of these had near-sighted parents. Of the children who were yet in their first half-year of school-life, only 0.4 per cent. were near-sighted. Thence, upward, through seven biennial grades, the percentage increased till it reached 63.6 per cent. of those who had been fourteen years at school. The disease was found also to be progressive in degree.

Results bearing a striking correspondence with these have since been reported by various eminent European oculists, chiefly the following: Of 4,358 examinations by Dr. Erismann, of St. Petersburg, in 1871; of 1,058 by Dr. Reusse, of Vienna, in 1872, '73, '75; of 3,036 by Dr. Conrad, of Königsberg, in 1874–'75; and of 1,846 by Dr. Pflüger, of Lucerne, in 1876.

The interest excited by these reports was not confined to European circles. But the conditions of school-life in this country were believed to be so much more favorable than in Europe, that these deplorable statistics, it was thought, could have no parallel here. Nevertheless, the examinations which have been made, as we shall show, furnish occasion for the deepest solicitude.

In New York the examinations were made by Dr. W. Cheatham; in Brooklyn, by Drs. Prout and Matthewson; and in Cincinnati, by Drs. Ayers and E. Williams. They had been furnished by Dr. Agnew with elaborate tables or forms, arranged like Cohn's, which they returned to him filled for summing up and comparison. In this he was assisted by Dr. Webster. The results are as follows:

New York College, 549 students: introductory class—near-sighted, twenty-nine per cent.; freshman class, forty per cent.; sophomore class, thirty-five per cent.; junior, fifty-three per cent.; senior, thirty-seven per cent.

Brooklyn Polytechnic, 300 students: Academic Department, ten per cent.; collegiate, twenty-eight per cent.

Cincinnati, 630 students: district schools, ten per cent.; intermediate, fourteen per cent.; normal high, sixteen per cent.

This report was read by Dr. Webster before the Social Science Congress at Detroit in 1875, and again by Dr. Agnew at the Medical Congress in Philadelphia, September, 1876. In the report of the proceedings of the latter body, for the *Medical Record*, October 14th, it is stated that "the section unanimously recommended to the Congress that the paper be published, with the statistical tables in full." Nevertheless, the paper has not yet been printed; but some of its conclusions may be found in the *Medical Record*, January 20th.

In February last, Dr. Lucien Howe was appointed, by the Buffalo

Medical Association, to examine and report upon the effects of study upon the eyes of pupils of the public schools of Buffalo. In March he reported that he had examined 1,003 scholars, of whom he found twenty per cent. to be near-sighted, and twelve per cent. over sighted; that not a single case of near-sight was found among the children six years old and under; but that at seven years of age five per cent. had acquired near-sight; at eleven there were eleven per cent.; at thirteen there were nineteen per cent.; and at eighteen twenty-six per cent. Among those who had continued in the schools beyond the age of twenty-one years, he found no less than forty-three per cent. with near-sight. He says that Dr. Agnew had sent him blanks for the name, age, sex, and height; for the exact size of desks and seats; also, for each room, the color of the walls, number of windows, and whether to the right, left, front, or rear; the number of square feet in each window, and the distance of adjoining buildings which might obstruct the light. Also, for methods of teaching by large objects, the hours of study, number of recesses, methods of heating and ventilation, and for the cubic feet of air to each individual. The greatest care was exercised to record: 1. The precise condition of the pupils' vision, whether healthy or not; and, if abnormal, to what degree. 2. The usual position of the body when studying. 3. Illumination of the school-room. 4. The relaxation given to the eye alone, or to the whole body. 5. The general hygienic surroundings of the pupil.

He then describes the process of individual examination: Half a dozen scholars at a time were sent into a class-room, on one of the walls of which had been hung a card of letters known to oculists as "Snellen's test-types." The scholars were placed at a distance of twenty feet from these letters, and asked to read the lowest line, the letters being $\frac{3}{8}$ inch Gothic. *Those who can pass this test are not near-sighted.* Then there is held before the eye of each a weak convex glass, such as old people are accustomed to wear. *If he cannot see so well as without it, he is not far-sighted.*[1] In some cases of unusually imperfect vision, the ophthalmoscope was employed.

During the summer of 1876, Dr. E. G. Loring, Jr., of New York, assisted by Dr. R. H. Derby, examined the sight of 2,000 pupils of the Twelfth Street public school and the normal school in Sixty-sixth Street, New York. Their ages ranged from six to twenty-one years. As in the other examinations cited, myopia was found to affect a very small percentage of the pupils in their first year, and to increase yearly and largely thereafter, to the close of school-life; and that the average *degree* of near-sight increases with the age up to twenty-seven years. His report was read before the Medical Congress in Philadelphia, in September, 1876.

In the fall of 1875, Dr. Hasket Derby, of Boston, commenced a

[1] These are approximate tests.

series of examinations at Amherst College, with the purpose of noting the progress of near-sight in the same class and in the same individuals. The freshman and sophomore classes—1,880 and 1,879—were required to report to him; and twenty-seven per cent. of the former and twenty-eight per cent. of the latter were found to be near-sighted. In the fall of 1876 they were again examined, when the disease was found to have progressed in one-half the number of those previously found to be myopic. In January, 1877, he examined the eyes of 122 volunteers from the freshman class of Harvard College—a little more than half the class—of whom 29.5 per cent. were found to be near-sighted. Of these, twenty-two per cent. had supposed their sight to be normal. He describes his blank-printed forms as—

"filled in with the name and age of each individual, the state of each of his eyes as separately tested by glasses and the ophthalmoscope, the amount of his vision, and remarks on his previous history and family peculiarities in this regard. Blanks are left for a similar examination at the close of the senior year."

In his report to President Eliot,[1] he urges the advantages to the student of—

"reliable information at the outset of his collegiate career as to the state of his eyes, their availability for study, and the course he must pursue to maintain their integrity, or keep existing evils from increasing. At the termination of his undergraduate course he learns the effect of his four years of study, and is thereby enabled to form or modify his future plans."

His report closes with an illustration of the development of near-sight in a person born free from it, but inheriting a strong tendency to it. During nine years—from the age of ten to nineteen—suggestions several times offered with regard to rest and treatment having been unheeded, a progressive change had occurred, ranging from perfect soundness in one eye, and a very slight degree—represented by "0.75"—of near-sight in the other, to a high degree of near-sight, represented by "5.50" in each. If advice and warning are still unheeded, he thinks "an amount of structural change may be brought about incompatible with the integrity of the eye through life."

But while it appears to be conceded that near-sight is of infrequent occurrence among the illiterate classes, the question is a very natural one, "Have examinations been made, for comparison, of the eyes of any classes of young persons other than those engaged in study?" Dr. Cohn examined the eyes of many peasant-children, living in a state of comparative simplicity, and having little or no occasion to tax or strain the sight, and found that hardly two in a hundred of them were near-sighted. Examinations have been made also of the sight of young factory-operatives in large manufacturing towns in Europe, and the results exhibit a low percentage of myopia, corresponding to that of the peasant-children here cited. Dr. Howe says:

[1] *Boston Medical and Surgical Journal*, March 22, 1877.

"Of 213 cases of eye-disease seen during the last year among the paupers of Buffalo, the record shows only three and one-half per cent. to have been near-sighted."

Donders remarked this difference between his private patients—representing the wealthy and cultivated class—and his hospital patients: that while over-sight was distributed between the two classes in nearly equal proportion, near-sight occurred much more frequently among his private patients.

The investigations of Dr. Peter A. Callan belong in this category, with a qualification. He examined the sight of 457 colored-school pupils, aged from five to nineteen years, of the New York public schools, Nos. 3 and 4, and he found but 2.6 per cent. of them near-sighted. This field was selected because it was thought to furnish the nearest approach to the normal eye to be found in this locality. The Southern freedmen, he thinks, would afford the best possible field for this special line of investigation. As a class, the colored people of New York, prior to this generation, had very limited educational advantages, and the occupations which tax the sight, like engraving, etc., have never been known among them. But as these 457 subjects are now receiving the best school-training that the city affords, the superior condition of their sight must be referred to their freedom from hereditary tendency to myopia. The conscientious painstaking and thoroughness of Dr. Callan's work, as exhibited in his report, are manifest and noteworthy.

The uniform drift of results in all the examinations here referred to, and relating to over 26,000 individuals, may be regarded as sufficiently establishing the following propositions:

1. That, as a rule, near-sight originates in school-life.

2. That a large percentage of the scholars are thus afflicted—the percentage progressing with the stage of advancement in study.

3. That near-sight is progressive *in degree*, according to the length of school-experience.

But, though the demonstration of these points is now complete, further and successive examinations will still be useful to determine the improvement consequent upon the adoption of means to that end, and to furnish a standard of comparison between different schools in respect to material or methods, or both—that is, first, in respect to arrangement of building, amount and direction of light, character and position of desks, seats, etc.; and, second, in respect to methods of teaching, especially in the earlier years, and generally to the intelligent observance and enforcement by the teachers of hygienic conditions. Dr. Howe's report is interesting in this feature, showing that "in schools where the hygienic conditions relating to the position of the pupils and the amount of light are disregarded, the proportion of near-sighted pupils grows larger; and conversely, where these relations are observed, the number diminishes;" and he gives

numerical rank "from an ophthalmic point of view" to the different schools examined by him.

Here arise two questions: 1. Can near-sight be cured? 2. Can it be prevented?

All authorities agree that it is incurable, and all agree that it may be prevented.

How?

The answer to this may be made more satisfactory if first we rapidly sketch a few well-known physiological facts, and get an understanding, approximately correct at least, of what near-sight is, and what causes it. Incidentally we shall have occasion to notice some of the methods and appliances for detecting both near-sight and over-sight.

When we see any object clearly, it is because the rays of light reflected or radiated from it enter the eye and produce a perfect picture of the object upon the retina. But the perfection of the picture depends upon the distance, size, and illumination of the object relatively to the powers and condition of the eye. The distance determines the angle at which the rays enter the eye. Whatever this angle, the rays must converge upon the retina, or the picture will be defective. This convergence it is the office of the lens to effect. From remote objects the rays are parallel, or nearly so. These, passing through the lens, are converged by it upon the retina. As the distance diminishes, rays entering the eye from any given point of the object become more and more divergent. Now, unless there be a corresponding increase in the convexity of the lens, these divergent rays will not be focalized at the same point as were the parallel rays; because, with the same power of lens, the focal distance must increase as the rays diverge; they will not, therefore, have converged when they reach the retina. A perfect picture will not be formed, and distinct vision will not be realized. But a change does take place in the lens corresponding to the change in the angle of the rays which enter the eye. As they diverge, its convexity increases. This is effected by the contraction of a muscle called, sometimes, *the muscle of accommodation*, which encircles the lens. Thus, the point of convergence is maintained upon the retina, in spite of the varying angle of the entering rays.

The normal location of the retina is that point at which parallel rays are converged, the lens being at rest. But if the eyeball loses its normal shape, and becomes elongated in the direction of its visual axis, the retina is thereby set back beyond the focal point. Convergence may be effected within the normal distance, but never beyond it; for, while the lens may become changed from its passive state to one of greater convexity, it cannot assume a convexity less than that of its passive state. Consequently, when the eyeball becomes elongated from front to back, the convergence will be at a point *in front*

of, instead of *upon*, the retina. This is near-sight, as it may be recognized by object-tests or trial-glasses. But near-sight is sometimes simulated. This is caused by a spasmodic action of the muscle of accommodation. To determine absolutely, therefore, whether or not the eyeball has taken this abnormal shape, or whether the apparent near-sight is due to this spasmodic action of the focalizing muscle, the oculist must paralyze that muscle. He does this by a simple and, in his hands, a harmless application of a weak solution of sulphate of atropia.[1] Then the object-tests and trial-glasses will determine the question with certainty. But, if it be impracticable to apply the atropia, then the ophthalmoscope[2] must be resorted to, as offering the nearest approach to certainty of results when the accommodating muscle cannot be paralyzed, because its contraction is not very likely to occur under the operation of that instrument. Thus provided, the oculist proceeds to examine the interior of the eye, and, his own eye being normal, and his own accommodation relaxed, if he sees the retina of the examined eye perfectly, he pronounces the refraction to be correct; or, technically, the eye is *emmetropic*. But, if he finds the retina is not clearly visible, there being no opacity of the refracting media, he knows it can only be because the rays reflected from the ophthalmoscope have not converged upon it. Assuming it to be a case of anterior convergence, he interposes a concave glass, which lengthens the focus and removes the point of convergence back upon the retina. Thereupon he pronounces the eye *near-sighted*; or, technically, *myopic*, of a degree indicated by the strength of the glass.

Near-sight, then, is that condition of the eye in which the rays from distant objects reach the retina AFTER *convergence.*

On the other hand, if, instead of the eyeball becoming elongated, it is flattened, then the visual axis is too short; that is, the retina is brought too near the lens, which consequently requires the contraction of the accommodating muscle to focalize the parallel rays upon the retina; whereas, had the eye been normal, the lens would have performed this function while in a state of rest, and would have required the contraction only for divergent rays.

[1] Though this is frequently done with individual patients, yet schools have generally objected to it. Dr. Cohn enjoyed an exceptional opportunity to examine the eyes of 240 scholars after the application of sulphate of atropia. Dr. Callan's colored subjects, he relates, refused to permit this application. Therefore, wishing "to place the results of his examination beyond dispute" in point of accuracy, he adopted the alternative course, and "kept both of his own eyes under the influence of a four-grain solution of sulphate of atropia, applied three times daily during a period of five weeks, so that the accommodation was completely paralyzed for that length of time." Sometimes the examining oculist has acquired the power to perfectly relax his accommodation at will. But the relaxation of the accommodation of *the subject*, as well as that of the examiner, is essential to entire accuracy.

[2] A small mirror with a hole in the centre. The mirror is held close to the patient's eye, so as to reflect into it the light of a gas-jet back of him. The oculist then places his eye close to the hole, and looks into the illuminated interior of the eyeball.

This condition is known as *over-sight*,[1] technically, *hypermetropia*. When it exists in a degree beyond the adjustability of the lens, it may be recognized by object-tests and trial-glasses; but in less degrees it may escape detection by these means, because of the accommodating action of the lens. As in the case of near-sight, therefore, atropia must be employed for its exact observation.

Over-sight may, then, be defined as that condition of the eye in which parallel rays, passively transmitted by the lens, reach the retina BEFORE *convergence, because of the shortened axis.*

While the subjects of this malformation are numerous, some investigators finding them even to exceed largely those of the opposite condition,[2] and while the eyes so malformed are usually *not diseased, as in myopia*, yet numerous local and general disturbances are found to exist in very many of the cases. These are the result of over-use, or straining of the muscle of accommodation. A special interest has recently been excited in reference to them by an address of Dr. George T. Stevens, of Albany, read last December before the Albany Institute,[3] in which the relation of cause and effect is claimed to have been established by the author, between certain visual defects, particularly over-sight, and such functional nervous affections as neuralgia, the more common forms of headache, epilepsy, St. Vitus's dance, hysteria, and insanity. About six months previously he had presented this theory to the New York Academy of Medicine, but he then limited its application to St. Vitus's dance. These views were "new and unexpected to the profession," and were controverted by Dr. Charles S. Bull, of New York, in a paper read before the New York Medical Journal Association, in April last.[4] He reports thirty-one cases of St. Vitus's dance in his own recent practice, in which special attention was given to the discovery of any such relation as Dr. Stevens affirms to exist. Fifteen of the thirty-one had correct and sixteen had defective vision (over-sight). Of the latter only five could be induced to purchase and wear the necessary correcting glasses. But in these five cases there should have been some improvement, at least, in the nervous symptoms consequent upon their wearing the glasses; this being, by the admission of Dr.

[1] This is not a disease, like near-sight, but a condition; and it is not acquired, but is congenital, always. It is also called *far-sight* and *long-sight;* but it is thus liable to be confused with an acquired condition—producing a similar result, as in the sight of old people—which is not a flattening of the eyeball itself, nor of the cornea and the lens, but it is an impairment of the power of accommodation due to the hardening of the lens, which usually occurs at about the age of forty-five years, and is often called *old sight*, but is technically known as *presbyopia*.

[2] *See* "A Preliminary Analysis of 1,060 Cases of Asthenopia occurring in the Practice of C. R. Agnew, M. D.," which shows hypermetropia 359 to myopia 121, or nearly three to one.

[3] NEW YORK MEDICAL JOURNAL for June.

[4] *Medical Record*, June 2d.

Stevens himself, "the crucial test" of the correctness of his theory. *Yet no such result was observed.* Nevertheless, in his later essay, he insists that "correction of the eyes of the patients does relieve their nervous symptoms. . . . This is no place," he says, before the Albany Institute, "to relate cures in medical practice; but, after a sufficiently extended and careful series of observations, continued during more than four years, I can safely prophesy that this principle will be found of more universal application, and more successful in its workings, than any which has been advanced for the mitigation of this class of affections."

The distressing confusion and disappointment resulting from the unbalanced action, in the over-sighted eye, between the arrangement for adjusting the lens and that for converging the eyeballs, is very clearly explained by Dr. Stevens in the same paper. Referring to its effect upon school-children he says:

"How often do we see children of our schools, frequently the brightest and most ambitious of their class, struggling with irritable nerves, at a disadvantage in their studies, laying the seeds of future trouble, and often, as the time comes for selecting a pursuit in life, forced to abandon a chosen course of studies, because the confinement at such work is too great a strain upon them! I look forward to the time when these children, who from this single peculiarity are placed at so serious a disadvantage in the struggle for life, shall find the relief that science is ready to afford them, and which would remove the weight that would otherwise prove a serious hinderance in their course."

Resuming now the consideration of near-sight, we proceed to suggest some of its principal causes, as follows:

1. Too early use by school-children of books, slates, and writing-paper, or copy-books, when blackboards and models would be better. Type and script letters and figures, and their primary combinations, at least, should never be taught from books, but from large and perfectly-formed models, printed on cards and hung on the wall. When the eye and the memory are sufficiently trained to easily recognize and name each letter and figure at sight, and when some knowledge has been gained of the power of letters and figures in combination, then the same forms in books will be at once familiar as old acquaintances, and may be studied without straining the sight. *To train the hand* without straining the sight presents a greater practical difficulty. In the large schools, of course, all the children cannot go to the blackboard. But a considerable practice in drawing large lines and simple objects on good-sized slates, in a sort of free-hand style, should precede the formation of letters and figures; and, when these are begun, they should be made of generous size. A correct position, meanwhile, should be an imperative requirement; and, until it becomes habitual and easy, good work should be held to be of secondary importance. Hard slate-pencils and greasy slate-surfaces should not be permitted; both should be subject to systematic inspection.

2. Ignorance or laxity on the part of parents and primary teachers, in permitting faulty positions of the head, body, and book, during reading, study, and writing; and in not seeking early to secure the intelligent coöperation of the pupil by simple and appropriate physiological instruction.

3. A prolonged and steady looking at an object or at objects near the eye, though at proper distance, without rest or frequent change of the visual focus, as in long and absorbed novel-reading, intense study, or persistent diligence in needlework.

4. The practice of reading or otherwise using the sight at too short range. This results in part from insufficient light; or from its faulty direction, so that the hand or body throws a shadow on the page; or so that the direct rays fall upon the eye, causing undue contraction of the pupil, while the page is in shadow. It results also from improperly graded desks, from small and poor type and inferior printing-ink, and from faulty color and quality of printing-paper; also from pale writing-ink—pale when used—and from the substitution of the lead-pencil for the pen, especially in the evening.

5. A prone or forward position of the head too long maintained, or frequently repeated, and becoming a habit. This results from reading or studying with the book in the lap, and from the use of desks not graded to the height of the pupil. Dr. Howe reports pupils varying eighteen inches in height seated at the same grade of desks. The distance of the eye from the page should not be less than twelve nor more than eighteen inches. Having the desks set too far from the seats also induces this faulty position. The front of the desk should overlap the seat one or two inches.

Donders says,[1] "In the hygiene of myopia the very first point is to guard against working in a stooping position." He favors high, sloping desks, and indicates "rectilinear drawing on a flat surface" as a class of work which is especially objectionable.

6. Since a vitiated atmosphere is a frequent feature of the schoolroom, it may not be amiss to add here that the effect of bad air is indirectly to injure, if not to destroy, the sight.

7. Allowing a sun-glare on the page while reading; also transitions from cloud-shadow to sunshine.

8. Reading and studying in railroad-cars is known to be a fruitful source of injury.

9. But insufficient light, perhaps more than any other cause, produces disease of the eye and derangement of the vision. This is not confined to the schools. Sadly frequent as it is found to be there, it is believed to be yet oftener illustrated at home, both by daylight and in the evening, in preparation for the school and otherwise. Artificial illumination is faulty at best, but, even in the most favored homes, the elder group is apt to monopolize the shaded drop-light or student-

[1] "Accommodation and Refraction," p. 419.

lamp, while the schoolboy with his text-books is found somewhere in the outer circle.

Twilight-reading is much practised, and is especially pernicious—that is, prolonging the study or reading after daylight has begun to decline. The change is so stealthy that, when the interest is excited, and the mind absorbed, the growing darkness is unheeded or unobserved, till serious mischief is done.

A curious and interesting case of injury to the sight by study is that of Prof. John Nott, late of Union College, Schenectady. Over thirty years ago his sight was permanently destroyed for all literary purposes, "by attempting," as he says in a recent letter to the writer of this, "too much study without thought of the necessity of care for the eyes." How many are following after him! In the same letter he thus describes his case as diagnosed by Dr. Alexander, of London, who alone of all whom he consulted was able to afford him even temporary and partial relief: "Thirty-six very small glands in the eyelids make *oil* for the eye, the same as oil for your lamp. When these glands become dry, reading is impossible, although in other respects the eye may be perfect. This was my disease—no oil was supplied to the eye." He makes or implies this noteworthy suggestion, which is hereby commended to authors, publishers, and school-boards: *that a brief and appropriate caution be conspicuously printed or pasted in the front of every school and college text-book, by authority of commissioners, superintendent, trustees, or faculty.* Something like the following would perhaps realize his idea:

CAUTION.—Reader, *your eyesight* is worth more to you than any information you are likely to gain from this book, however valuable that may be. You are therefore *earnestly cautioned*—

1. To be sure that you have sufficient light, and that your position be such that you not only avoid the direct rays upon your eyes, but that you also avoid the angle of reflection. In writing, the light should be received over the left shoulder.

2. That you avoid a stooping position and a forward inclination of the head. Hold the book up. Sit erect also when you write.

3. That at brief intervals you rest the eyes by looking off and away from the book for a few moments.

And you are *further cautioned* to avoid as much as possible books and papers printed in small type, and especially such as are poorly printed; also to avoid straining or overtaxing the sight *in any way.*

Boys may need to be reminded of the great importance of thoroughly cleansing the eyes with soft, pure water both morning and evening.

To many readers it would no doubt be interesting to consider how each of the practices and conditions we have pointed out as producing

near-sight tends to effect the elongation of the visual axis. But while there might be no disagreement among oculists as to the fact that the practices and conditions named do thus tend, there may not be a consonance so general as to the precise process in every case A few general suggestions, however, are submitted:

1. The *rationale* of the effect of the premature use of books, etc., during the more plastic condition of the eye is sufficiently obvious.

2. A prolonged tension of the sight lessens the muscular elasticity.

3. The contraction and consequent thickening of the muscles which pull the two eyes inward, so as to focalize the sight upon a near object, causes a side-pressure, and a corresponding transverse or lengthwise protrusion. The nearer the object, the stronger must be this action of the muscles, and the more marked the effect.

4. The prone position of the head causes the blood to settle in the eyeballs, increasing the tension of the fluids, exciting inflammation and consequent softening of the coatings, and resulting in permanent distention.

The attentive reader cannot have failed to observe that we have enumerated causes of injury to the eyes from study, other than those which produce near-sight. Of these, only one seems to require reference—the effect of bad air in the school-room.

Dr. Loring read a paper in February last before the Medico-Legal Society of New York, answering four questions relating to the care of the eyesight, which had been submitted to him by that Society. The first of the series inquires the effect of bad air on the sight.[1] His reply, given at some length, supports the statement herein made.

In a recent conversation with the writer, Dr. Loring advocated examinations of the sight of all children when they first enter school, and at such subsequent stages of their education as might seem desirable. The position of a child's seat relatively to the blackboard, etc., would often be governed by such an examination. He thought, too, that glasses would be recommended in some cases by the examining oculist—a permanent official he would have him to be—and that, if necessary, they should be furnished at the public expense, or out of some special fund; the glasses to be worn during school-hours at least, if not continuously. He related the circumstance of a lad having been recently brought to him by his father from the West. An examination verified the boy's statement that he could see to read usually very well; but that sometimes, in a moment, his sight would be so affected that reading became impossible. This had led to his repeated punishment at school, his averment of inability not being credited by his teacher.

[1] *Medical Record*, April 14th.

THE GIGANTIC MOA-BIRD.

THE extinction of many animals that are known to have formerly existed on the earth is a subject which cannot very easily be explained, while the number of them is greater than at first sight would be supposed. Various species no doubt undergo gradual extinction by changes which deprive them of their accustomed food; but others seem to die out from unknown causes. During the historic period a considerable number of animals have been swept off the British Islands, among which are the bear, the wolf, the Irish elk, etc. In America, during the comparatively short period of its history, various species have vanished, and others are following them. The beaver, formerly so generally spread over the whole of that country, is now only to be found in remote regions. The deer and the moose are disappearing in the same manner. The bison is very much diminished in numbers, and must ere long be extirpated. The mastodon, a creature of enormous bulk, has totally disappeared, although, along with the skeletons of them which have been discovered, there are evidences of their having lived on food derived from plants which are still existing. In other parts of the world, the dodo and the moa have perished within the last few centuries; and the apteryx is undergoing the same fate.

The moa or dinornis was a huge bird, of which the remains are plentifully found in New Zealand. Within recent historic times, this colony was tenanted, to the almost entire exclusion of mammalia, by countless numbers of gigantic wingless birds of various genera and species, the *Dinornis gigantea*, the largest, attaining a size nearly thrice that of a full-grown ostrich. From traditions which are current among the Maoris, they were fat, stupid, indolent birds, living in forests and feeding on vegetables; while the name *moa* seems to have been given to them from their peculiar cry. Since remains have been found in great plenty, the investigation of this singular bird is of the greatest interest to students of natural history.

DINORNIS GIGANTEA.

It is to the Rev. Richard Taylor that the first discovery of moa remains is due, which he thus describes:

"In the beginning of 1839 I took my first journey in New Zealand to Poverty Bay with the Rev. W. Williams, Bishop of Waiapu. When we reached Waiapu,

near the East Cape, we took up our abode in a native house, and there I noticed the fragment of a large bone stuck in the ceiling. I took it down, supposing at first that it was human; but, when I saw its cancellated structure, I handed it over to my companion, who had been brought up to the medical profession, asking him if he did not think it was a bird's bone. He laughed at the idea, and said, 'What kind of a bird could there be to have so large a bone?' I pointed out its structure, and, when the natives came, requested him to ask them what it belonged to. They said it was a bone of the *tarepo*, a very large bird, that lived on the top of Hikurangi, the highest mountain on the east coast, and that they made their largest fish-hooks from its bones. I then inquired whether the bird was still to be met with; and was told that there was one of an immense size which lived in a cave, and was guarded by a large lizard, and that the bird was always standing on one leg. The chief readily gave me the bone for a little tobacco; and I afterward sent it to Prof. Owen by Sir Everard Home in 1839; and I think I may justly claim to have been the first discoverer of the moa."

Mr. Taylor continued his inquiries among the natives, who informed him that the moa was quite as large as a horse; that these birds had nests made of the refuse of fern-root, on which they fed; and that they used to conceal themselves in the veronica-thickets, from which, by setting them on fire, the natives drove them out, and killed them; hence originated the Maori saying, "The veronica was the tree which roasted the moa." The natives further mentioned that when a moa-hunt was to take place notice was given inviting all to the battue. The party then spread out to inclose as large a space as possible, and drive the birds from their haunts; then, gradually contracting the line as they approached some lake, they at last rushed forward with loud yells, and drove the frightened birds into the water, where they could be easily approached in canoes and dispatched without their being able to make any resistance. These moa-hunts must thus have been very destructive; as, from the number of men employed, and the traces of long lines of ovens in which the natives cooked the birds, and the large quantity of egg-shells found on the western shores of New Zealand, a clear proof is given that these birds were eagerly sought for and feasted upon. Thus the poor moas had very little chance of continuing their race.

From a very interesting communication of the Rev. W. Williams, dated May 17, 1872, it would appear that the moa may not yet be entirely extirpated. He remarks:

"Within the past few days I have obtained a piece of information worthy of notice. Happening to speak to an American about these bones, he told me that the bird is still in existence in the neighborhood of Cloudy Bay, in Cook's Strait. He said that the natives there had mentioned to an Englishman, belonging to a whaling-party, that there was a bird of extraordinary size to be seen only at night on the side of a hill near the place; and that he with a native and a second Englishman went to the spot; that after waiting some time they saw the creature at a little distance, which they describe as being about fourteen or sixteen feet high. One of the men proposed to go nearer and shoot; but his companion

was so exceedingly terrified, or perhaps both of them, that they were satisfied with looking at the bird; when after a little time it took the alarm and strode off up the side of the mountain."

In the *Greymouth Weekly Argus*, published in New Zealand in 1876, there appeared a letter signed R. K. M. Smythe, Browning's Pass, Otago, describing in a very detailed manner the capture of two living moas, a female eight feet high, and a younger one three feet shorter. The writer finishes his account of their capture by remarking that he has little doubt that he will be able to bring them both alive to Christchurch. It is therefore to be hoped that living representatives of the genus *Dinornis* still survive. Feathers of the bird have been also found in a state of preservation sufficiently good to show that they possessed an after-shaft of a large size; and at the same time tradition and the condition in which the bones are found, retaining much of their animal matter, tend to show how lately the bird formed part of the existing fauna of the country. If the letter be genuine, it cannot be long before ornithologists, of whom there are several of no mean repute in New Zealand, will be able to satisfy themselves on the subject.

An additional reason for supposing that these magnificent birds existed not long ago is found in the fact that specimens of their eggs have been preserved. In the volcanic sand of New Zealand, Mr. Walter Mantell found a gigantic egg, of the magnitude of which he gives us a familiar idea by saying that his hat would have been just large enough to have served as an egg-cup for it. This egg must have been one of a dinornis or a palapteryx, and, although its dimensions are considerably greater than the egg of the ostrich, still it is smaller than might have been expected from a bird from twelve to fourteen feet high. It is well known that the egg of the New Zealand apteryx, to which the moa bears a very close affinity, is one of dimensions that are quite surprising in proportion to the bulk of the bird. The apteryx is about as big as a turkey, standing two feet in height; but its egg measures four inches ten lines by three inches two lines in the respective diameters. To bear the same ratio to the bird as this, the egg of the *Dinornis gigantea* would be of the incredible length of two feet and a half, by a breadth of one and three-quarters!

In the museum at York there is a complete skeleton of a moa, which, besides feathers, has the integuments of the feet partly preserved; from which it is evident that the toes were covered with small hexagonal scales. A specimen has also been sent by Dr. Haast, of New Zealand, to Prof. Milne-Edwards, which is to be seen in the Museum of Natural History at Paris.—*Chambers's Journal.*

TO THE "RING NEBULA."

By J. L. STODDARD.

O PALLID spectre of the midnight skies!
Whose phantom features in the dome of Night
Elude the keenest gaze of wistful eyes
Till amplest lenses aid the failing sight,
On heaven's blue sea the farthest isle of fire,
From thee, whose glories it would fain admire,
Must vision, baffled, in despair retire!

What art thou, ghostly visitant of flame?
Wouldst thou 'neath closer scrutiny dissolve
In myriad suns that constellations frame,
Round which life-freighted satellites revolve,
Like those unnumbered orbs which nightly creep
In dim procession o'er the azure steep,
As white-winged caravans the desert sweep?

Or art thou still an incandescent mass,
Acquiring form as hostile forces urge,
Through whose vast length a million lightnings pass
As to and fro its fiery billows surge—
Whose glowing atoms, whirled in ceaseless strife
Where now chaotic anarchy is rife,
Shall yet become the fair abodes of life?

We know not; for the faint, exhausted rays
Which hither on Light's wingèd coursers come,
From fires which ages since first lit their blaze,
One instant gleam, then perish, spent and dumb!
How strange the thought that, whatsoe'er we learn,
Our tiny globe no answer can return,
Since with but dull, reflected beams we burn!

Yet this we know: yon ring of spectral light,
Whose distance thrills the soul with solemn awe,
Can ne'er escape in its majestic might
The firm control of omnipresent law.
This mote descending to its bounden place,
Those suns whose radiance we can scarcely trace,
Alike obey the Power pervading space

SKETCH OF MICHAEL SERVETUS.[1]

By M. MAURIS.

THE publication of an elaborate life of Servetus in English at the present time will be welcome to many readers, who at present know little more of the man than that he was burned at the stake at Geneva, at the instigation of John Calvin, three hundred and twenty-five years ago. The progress of the world from polytheism to monotheism has had many tragic passages, but perhaps the most unique was this roasting alive of the Unitarian Servetus with green wood by a leader of the Protestant Reformation.

Dr. Willis, the author of the work, had edited an edition of the writings of William Harvey, accompanied by a biography of the great demonstrator of the circulation of the blood. His researches into this interesting subject led him to investigate the claims of Servetus to a share in this grand discovery, when it was established that he was "the first who proclaimed the true way in which the blood from the right reaches the left chambers of the heart by passing through the lungs, and even hinted at its further course by the arteries to the body at large." His study of the subject deepened the interest of Dr. Willis in the character of Servetus, not only as a physiologist, but as a philosopher and scholar; as a practical physician, freed from the fetters of mediæval routine; an eminent geographer and astronomer, and a liberal Biblical critic in days when criticism, as we understand the term, was unimagined.

Servetus was a Spaniard, born at Villanueva, in Aragon, in 1509, of an old family in independent circumstances. He entered the University of Saragossa when about fourteen years old, and there perfected himself in the study of the classics, in the Greek and Hebrew tongues, as well as in the ethics of Aristotle, scholastic philosophy, mathematics, astronomy, and geography. From Saragossa he appears to have passed to the law-school of Toulouse, but theology had more attractions for him than law. A rational exposition of God's revelation of himself in Nature seems to have been a craving in the ardent and religious temperament of the thoughtful young Spaniard. While at Toulouse he read the Bible, the writings of Luther, the rational theology of Rymund de Sabunde, and the works of Erasmus. The effect of these studies was that, at eighteen years of age, he had already framed a theological system of his own, far in advance of the ideas of his time. Leaving Toulouse, Servetus entered the service of Juan Quintana, a Franciscan friar, and confessor of the Emperor Charles V., whose coronation he attended in Aix-la-Chapelle, and also

[1] "Servetus and Calvin: A Study of an Important Epoch in the Early History of the Reformation." By R. Willis, M. D. 541 pages. London: Henry S. King & Co.

the Diet of Augsburg, which closely followed it. Servetus was in sympathy with the Reformers of the Lutheran Reformation, and, in fact, came into conflict with them, because he did not think they were sufficiently rational and thorough-going, and what he saw of the pomp and tyranny of princes and bishops was not calculated to quiet the spirit of protest that early took a powerful hold upon his mind. At the age of twenty he writes: "For my own part, I neither agree nor disagree in every particular with either Catholics or Reformers. It would be easy enough, indeed, to judge dispassionately of everything, were we but suffered without molestation by the churches freely to speak our minds; the older exponents of doctrine, in obedience to the recommendation of St. Paul, giving place to younger men, and these, in their turn, making way for teachers of the day, who had aught to impart that has been revealed to them. But our doctors now contend for nothing but power. The Lord confound all tyrants of the Church! Amen."

With such views, and a constitutional temperament that knew no fear, and led him to the free expression of his opinions, he was, of course, soon dismissed from the service of Quintana. He then threw himself, body and soul, into the study of theology, and in 1530 we find him at Basle, Switzerland, disputing with Œcolampadius and other theologians on the consubstantiality and coeternity of the Son with the Father, and other points in connection with the idea of the Trinity then prevailing among Catholics as well as Reformers. Being unable to make his views acceptable to the Reformer of Basle, he proceeded to Strasburg to propound his docrines to Martin Bucer and W. F. Capito, but with no better results. Meanwhile, he had not been otherwise idle; he had written a book in which his new opinions concerning Christianity were fully explained, and he resolved upon having it printed, to make the world judge between him and the other Reformers. He was in Germany, the land of free thought, as he imagined, and among men who had thought freely: why should he not avail himself of the same right? The names of Luther, Calvin, etc., appeared on the title-pages of their works: why should his name be withheld from the world? Accordingly, the "Seven Books on Mistaken Conceptions of the Trinity" appeared with the author's full family name, and the name of the country that called him son.

As he appears in this book, Servetus may be considered as the founder of the doctrine of real monotheism, as it was possible to conceive it in the sixteenth century. We are sorry to be unable to give more than a passing notice of the chief points discussed in this work. He believed in a kind of Trinity, but modal and formal, not real and personal in the usual sense of the word. "God cannot be conceived as divisible," he says; he acknowledges a Son of God and a Holy Ghost, finding them in the Scriptures, no word of which he would overlook, though putting his own interpretation on all they say.

"The word Trinity," he writes, "is not to be found in Scriptures. The Son and the Holy Ghost are no more than so many forms or aspects of Deity. . . . To believe," he continues, "suffices, it is said (to salvation); but what folly to believe aught that cannot be understood, that is impossible in the nature of things, and that may even be looked on as blasphemous! Can it be that mere confusion of mind is to be deemed an adequate object of faith?" Speaking of the Holy Ghost, Servetus forgot what is due to a subject that has engaged the serious thoughts of so many pious and learned men. He saw some portions of the Catholic Christian dogma so unreasonable as to be unable to refrain from ridiculing them. Yet the idea of God to which Servetus had attained is unquestionably pure and grand—the only one, in fact, as we see the subject, that can be reasonably held by a true idealist. He also deals heavy blows at the doctrine of justification by faith, the leading feature of Luther's theology, in terms neither complimentary nor respectful to its author; nor less roughly dealt with is the leading Calvinistic theory of predestination and election.

The book seems to have caused a considerable stir both in Germany and Switzerland, to have found proselytes in Italy, and to have been read by every one of liberal education. Some of the antagonistic Reformers themselves could not forbear being strongly impressed with it. Œcolampadius, writing to Martin Bucer, July 18, 1531, says: "Read the book, and tell me what you think of it; as the writer does not acknowledge the coeternity of the Son, I can in no wise approve of it as a whole, although it contains much that is good." Melanchthon writes to a friend, "I read Servetus a great deal." He does not agree with the author, but "I have little doubt," he continues, "that great controversies will one day arise on this subject as well as on the distinction of the two natures in Christ."

"The Reformers of the sixteenth century," Dr. Willis says, "went little way in freeing the religion of Jesus of Nazareth from the accretions which metaphysical subtilty, superstition, and ignorance of the laws of Nature, had gathered around it in the course of ages. Their business, as they apprehended it, was to reform the Church—the task Servetus had set himself, in the end, was to reform *religion*, with little thought of a church, in any sense as it was conceived in his day either by papists or Protestants." How could a book in this direction be welcome to the Reformers? It was too far in advance of their ideas; Servetus's dialectics were too stringent, and his arguments too conclusive against them.

After writing a splendid letter to Œcolampadius, for which we regret to have no room, he quitted Switzerland, whither he had returned after the publication of his book at Hagenau; and here he seems to have again taken up his quarters for some weeks or months, to write and superintend the printing of the "Two Dialogues on the

Trinity." Under color of modifying some of the views enunciated in his first work, he now cast the concluding anathema against all tyrants of the Church, as a parting shot, and off he went to France, reaching Paris toward the end of 1532.

If Switzerland and Germany "were too hot for him," Roman Catholic France would have proved still hotter; but during the time he lived in that country he never made himself known save as "Monsieur Michel Villeneuve," from the town of his nativity. He entered as a student of mathematics and physics at one of the colleges of Paris, and lived very quietly. At a later period he took his degree of M. A. in the University of Paris.

But the study of mathematics had soon to be abandoned for present means of subsistence. After a short stay at Avignon and Orleans, Villeneuve betook himself to Lyons, then a great centre of learning. There he seems to have found ready employment as reader and corrector of the press, first, and afterward as editor in the celebrated printing-establishment of Trechsel Brothers. Among the works he edited for them, the "Geography of Ptolemy," enriched by extensive comments from him, can by no means be overlooked, connected as it is with the charges imputed to its editor, later on, in his trial at Geneva.

The reading-room of the printers of Lyons, and the acquaintance Servetus formed there with the great physician and naturalist, Dr. Champier, brought the former back from the empyrean of metaphysics to the earth, and put him in the way of becoming the geographer, astrologian, Biblical critic, physiologist, and physician, with whom we are made familiar in his subsequent life and writings. With the money he had saved in the two years spent with Trechsel, he went back to Paris (1536), and gave himself to the study of medicine. He became at once associated with scientists as distinguished as Andreas Vesalius, the creator of modern anatomy, and Joannes Guinterus; and in a singularly short time he obtained the degree of M. D. With the stimulus of necessity upon him, for he was poor, and the excitement of ambition, with which he was largely endowed, as he found it hard to earn a living by his profession, Servetus appeared before the world as lecturer on geography and astrology—which then embraced the true doctrine of the heavenly bodies, as well as the false one of their influence on the life of man; and in this capacity he achieved an enormous success. Next he came forward in connection with his profession by writing a book on "Medicinal Sirups and their Use," thus winning fame also as a physician. A fiery struggle was going on during the early part of the sixteenth century between the Averrhoists and the Galenists. Like his initiator into medical matters, Dr. Champier, Servetus was himself a Galenist; but in this character, too, he showed the independence of his nature, by having open eyes for any truth which the Arabian writers and their followers might present.

Servetus's fate on starting in life was opposition. Through supe-

rior endowment and culture, he found himself antagonistic to almost all around him; his convictions were deep, and the haughtiness and violence of his disposition made it impossible to suppress them. The physician, therefore, met the fate of the theologian. It seems that he had gone out of the way, in his lectures, to accuse his fellows of ignorance, at least, of astronomy. The doctors of the faculty retaliated by denouncing him from their chairs as an impostor and a windbag. Servetus then wrote a pamphlet, in which he laid bare the sore places in the characters of his adversaries, even holding them up, in their ignorance, as the pests of society. His intentions being made known, the Senate of the University and the Parliament of Paris were petitioned to forbid the publication of the pamphlet; but Servetus outwitted them—before the day of citation came, the dreaded pamphlet was distributed to the public. The faculty of medicine had him summoned before the inquisitor of the king as an enemy of the Church, on the score of heresy, implied in the practice of judicial astrology. So thoroughly, however, did he satisfy the inquisitor that he was a good Christian, that he left the court with flying colors, absolved even of all suspicion of heresy. The doctors, however, in the end, won the day. The award of the Parliament ordered Michael Villanovanus to call in his pamphlet and deposit the copies in the court; to pay all honor to the faculty and its members; and he was expressly forbidden to appear in public or in any other way as a professor of astrology.

Villeneuve now moved to Charlieu, near Lyons, where he resumed the practice of medicine. While at Charlieu (1539), having attained his thirtieth year, according to the religious tenets he professed, he had himself baptized.

Pierre Paumier, one of his Paris admirers and friends, and now Archbishop of Vienne, hearing of his whereabouts, invited him to quit the narrow field of his practice for a wider one. Villeneuve accepted, and for the next twelve years he lived in Vienne, under the immediate patronage of the eminent prelate.

Besides practising medicine, he resumed his connection with the publishers of Lyons, and among other works edited the Latin Bible for Trechsel, with comments of his own. From his long studies in the Scriptures he had come to the conclusion that, while the usual prophetical bearing ascribed to the Old Testament was ever to be kept in view, the text had a primary, literal, and immediate reference to the age in which it was composed and to personages, events, and circumstances, among which the writers lived; and, according to this plan, he carried out the work. Yet Spinoza, Astruc, and others, who lived a century later, are called the founders of the modern school of Biblical exegesis, and Servetus is not even named as a Biblical critic and expositor!

We have now arrived at a momentous event in the life of Servetus

—his theological correspondence with John Calvin. It seems to have been entered upon at the suggestion of John Frelon, one of the Lyons publishers.

Servetus has been accused of having provoked the Genevese Reformer by addressing him in a style calculated to wound, if not to insult, him; and the character of the man gives likelihood to the charge. But, had Calvin's letters been preserved, we doubt whether the accusation would hold good; we know for a certainty that the great Reformer applied very freely the lowest epithets to his opponents—"rascal, dog, ass, and swine, being found of constant occurrence among them—had there been any stronger than scoundrel and blasphemer, they would have been hurled at Servetus." Calvin's own letter to Frelon, their go-between, throws a great light on the subject. Among other things, he writes: "I have been led to write to him more sharply than is my wont, being minded to take him down a little in his presumption; and, I assure you, there is no lesson he needs so much to learn as humility." At any rate, Villeneuve approached the Reformer, at first, as one seeking aid and information from another presumed most capable of giving both. Calvin replied in a concise, dogmatic way which, indeed, could not satisfy a mind as thoroughly made up as that of Servetus. Moreover, the Reformer soon grew weary of the correspondence, so that Frelon had to interpose in behalf of the Spaniard in order to make the former answer his letters. Nor is this all: thinking he might escape further molestation, Calvin referred Servetus to his book, "Institutions of the Christian Religion," as though he had been a schoolboy who had entered upon a discussion with the Reformer, with no knowledge of his doctrines. Villeneuve now became his critic. The copy of the "Institutions" was sent back, copiously annotated in the margin. There was hardly a proposition in the text that was not taken to pieces by him and found untenable on the ground of Scriptures and patristic authority, and this he did with the freedom of expression in which Villeneuve indulged. Calvin, in writing to a friend, indignantly says, "There is hardly a page that is not defiled by his vomit." "The liberties taken with the 'Institutions,'" Dr. Willis says, "were looked on as a crowning personal insult by Calvin; and reading, as we do, the nature of the man, it is not difficult to conclude that it was this offense, superadded to the letters, which put such rancor into his soul as made him think of the life of his critic as no more than a fair forfeit for the offense done." As a matter of course, the correspondence was soon dropped by Calvin, but not so by Servetus, who seemingly could not bear his opponent's neglect; over thirty letters of his, embracing a period of more than two years, are still extant.

Servetus meanwhile had prepared another book, "Christianismi Restitutio" (The Restoration of Christianity)[1] with which he intended

[1] The "Christianismi Restitutio" of Servetus is one of the rarest books in the world.

to bring religion back to more winning simplicity and purity. Having made a MS. copy of it, he sent it to Calvin, requesting an opinion on its merits. It was on its reception that, writing to his friend Farel, Calvin made use of the following language: "Servetus wrote to me lately, and besides his letter sent me a great volume full of his ravings, telling me with audacious arrogance that I should there find things stupendous and unheard of until now. He offers to come hither if I approve; but I will not pledge my faith to him: for, did he come, if I have any authority here, *I should never suffer him to go away alive.*" We see already by what feeling Calvin was animated: he hates the man who did not acknowledge his superiority, as he was accustomed to see others do, and who dared to criticise his opinions. Not only did he not even condescend to offer any strictures upon Servetus's work, but he never sent back the MS., although repeatedly asked for it.

Servetus, who had kept another copy for himself, determined to have the book printed anonymously. Arrangements were made with Balthasar Arnoullet, printer at Vienne, and, as secrecy was of capital importance, a small house away from the known printing-establishment was taken; type, cases, and a press, were there set up, and in a period of between three and four months an edition of 1,000 copies was successfully worked off. The whole impression was then made up into bales of 100 copies each, and confided to friends at Lyons, Frankfort, etc., for safe-keeping, until the moment of putting them in the market abroad had come.

The book on "The Restoration of Christianity" comprises a series of disquisitions on the speculative and practical principles of Christianity as apprehended by the author; thirty of the letters he had written to Calvin; and other writings of minor importance. It is in this book that Servetus shows himself the most far-sighted physiologist of his age, by anticipating the discovery of the circulation of the blood.

Through Frelon a copy of the book, "hot from the press," was especially addressed to "Monsieur Johann Calvin, minister of Geneva." We leave for the reader to imagine what additional anger must now have entered the Reformer's heart, when, besides the offensive and, as he regarded it, heretical matter of the book, he found the letters written to him made public, himself publicly schooled, his most cherished doctrines proclaimed derogatory to God, and some of them as barring the gates of heaven! What the reader, perhaps, could not imagine is, that the "high-minded" man who had emphatically denounced the "right of the sword" in dealing with heresy, was now ready to become instrumental in having it applied to Servetus. He became the denunciator of Servetus to the Catholic authorities of Vienne; he betrayed friendship and trust by furnishing them with

Of the thousand copies printed, two only are now known to survive: one among the treasures of the National Library of Paris, the other among those of the Imperial Library of Vienna.

the documents (letters and leaves from the printed book as well as the MS. copy which he had kept) that would bring about his conviction, and consequently his death. And this was not done openly. Calvin sent the wanted information through a convert to the Reform, a young man by the name of William Trie. Did not the style of Trie's letters and the documents show plainly the part played by the Reformer in the treason, he might be easily absolved from the charge —so cautiously had he worked to keep his treachery a mystery. Servetus was arrested and tried; he only avoided being burned alive by making good his escape from prison (April 17, 1553), in which he seems to have been aided by some devoted friend. All the books, however, that could be found, were seized and burned, together with his effigy.

Escaped from the prison of Vienne, after rambling some weeks through Southern France, he fled to Geneva. His choice of this place can hardly be accounted for. Perhaps, though he knew that Calvin had been his denunciator, it never entered his mind that the Reformer would now take the knife in hand himself. In the early morning of some day after the middle of July, he entered Geneva and put up at a small hostelry on the banks of the lake, where he seems to have lived very privately for nearly a month. On Sunday, August 13th, he ventured imprudently to show himself at the evening service of a neighboring church. Being recognized, Calvin was informed of his presence, and without a moment's delay he again denounced him, and demanded his arrest. Servetus was at once thrown into the common jail of the town.

According to the laws of Geneva, grounds for an arrest on a criminal charge were to be delivered within twenty-four hours thereafter. Calvin worked all night, and thirty-eight articles drawn from the "Christianismi Restitutio" were in due time presented in support of the charge. Another law prescribed that criminal charges should be made by some one who avowed himself aggrieved, and was contented to go to prison with the party he accused, the law of retaliation disposing of him in case his charges were not made good; and Calvin complied with this law, too, by means of a substitute. His cook, Nicolas La Fontaine, was the man who now came forth as "personally aggrieved by," and prosecutor of, Michael Servetus!

The main charges against the Spaniard were: his having troubled the churches of Germany, about twenty-four years previously, with his heresies and with an execrably heretical book, by which he had infected many; having continued to spread poison abroad with his "Comments to the Bible," the "Geography of Ptolemy," and lately with his "Restoration of Christianity;" having blasphemed against the Trinity, the Sonship of Christ, his consubstantiality with the Father, and proclaimed infant baptism a diabolic invention; having escaped from the prison of Vienne; and, finally, "of having in his

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printed books made use of scurrilous and *blasphemous* terms of reproach in speaking of Monsieur John Calvin and his doctrines."

Servetus's reply in his preliminary interrogatory was: that he was not conscious of having caused any trouble to the churches of Germany, and defied any one to prove it; that he was unaware that the book he owned to have had printed at Hagenau had produced any evil; that it was true he had commented on the above-mentioned books, but he had said nothing in them that was not the truth; and in the book lately printed he did not believe that he blasphemed, but if it were shown that he had said anything amiss, he was ready to amend it; that in the book he wrote on the Trinity he had followed the teaching of the doctors who lived immediately after Christ and the apostles; that previous to the Council of Nicæa no doctor of the Church had used the word *Trinity;* that his strong language against the Trinity, as apprehended by the modern doctors, was suggested by the belief that the unity of God was by them denied or annulled; that as regards infant baptism it was his belief that none should be baptized who had not attained the years of discretion; but he added, as ever, that if he were shown to be mistaken, he was ready to submit to correction; that Calvin had no right to complain of the respondent's abusive language, as he had been himself publicly abused by Calvin: he had but retaliated, and shown him from his writings that he was mistaken in many things.

On August 15th the council was formally installed as a court of criminal judicature, and the trial commenced; the answers of the prisoner to the articles being generally in the terms of his previous examination. The court closed the meeting with making good a petition of Nicolas La Fontaine to be discharged from prison, Servetus himself having given sufficient *prima-facie* evidence of his guilt. Bail was, however, required; and this was immediately forthcoming in the person of Monsieur Antoine Calvin, brother of the Reformer. The *chef de cuisine* was discharged, while Servetus was remanded to jail. About this time, in a letter to his bosom friend Farel, after relating the events of Servetus's arrest and of the proceedings against him, Calvin wrote, "I hope the sentence will be capital *at least.*"

It would be most interesting to follow this unprecedented sham-trial in all its details, as Dr. Willis has done; but want of space limits us to mere outlines of it. The party of free thought, or Libertines, showing sympathy for the prisoner, the trial assumed the character of a struggle between the two factions in Geneva. It was necessary for Calvin to nip in the bud the new growth of rebellion against his authority; and, throwing aside disguise, he now came forward as prosecutor of Servetus. The Spaniard's opinions differed so obviously from all they had ever been led to believe, that it was easy for Calvin to satisfy the majority of the judges of Servetus's culpability on theological grounds. It seems, however, that a feeling in favor of the

prisoner prevailed in the court; the Swiss churches, which on a similar occasion had decided against Calvin, were appealed to for advice, and the proceedings were postponed. It is pitiful to see how Calvin had set his heart on the condemnation of Servetus. He interfered with the course of justice by threatening the weakest among the judges, by stirring the feelings of his party in the council; he denounced and vilified his opponent from the pulpit in no measured terms, exposing his opinions in their most glaring and repulsive aspects; he tampered with the ministers of the Swiss churches; he formulated new and more elaborate articles of accusation, and to these, besides his own, had the signatures of thirteen of his fellow-ministers appended—in one word, he left no stone unturned to wreak his revenge. He wanted Servetus's death! The arguments and authorities piled against him by Calvin were so many, and the proceedings became so intricate, that Servetus was forced to request that he might be furnished with books, and have pen, ink, and paper, supplied, in which to epitomize his defense. The jailer was directed to give him the books he wanted, and a *single sheet* of paper!

On this "famous" sheet, Servetus, after demonstrating that civil tribunals are incompetent to decide on questions bearing on religion only, and that heretics were either to be brought to reason by argument, or punished by banishment, and not by prison, concludes:

"Secondly, my lords, I entreat you to consider that I have committed no offense within your territory; neither, indeed, have I been guilty of any elsewhere: I have never been seditious, and am no disturber of the peace. During all the time I passed in Germany, I never spoke on such subjects" (his theological views), "save with Œcolampadius, Bucer, and Capito; neither in France did I ever enter on them with any one. I have always disavowed the opinions of the Anabaptists, seditious against the magistrate, and preaching community of goods. Wherefore, as I have been guilty of no sort of sedition, but have only brought up for discussion certain ancient doctrines of the Church, I think I ought not to be detained a prisoner, and made the subject of a criminal prosecution.

"In conclusion, my lords, inasmuch as I am a stranger, ignorant of the customs of this country, not knowing either how to speak or to comport myself in the circumstances under which I am placed, I humbly beseech you to assign me an advocate to speak for me in my defense."

If a shadow of justice had ruled the trial, this petition would have met with success; but the court took no notice of it. "Skilled in lying as he is," said the attorney-general, Calvin's tool, "there is no reason why he should now demand an advocate."

After the sitting of September 1st, in compliance with a wish previously expressed by the court, Calvin, surrounded by a staff of ministers, proceeded to the jail to visit the prisoner. Calvin having then opened upon him with a bigoted lecture, the consequences are easily imagined: the interview ended as it could only end—with increased irritation on both sides. From this time (and we cannot but excuse the man), Servetus became more intemperate and aggressive on Cal-

vin; not only indisposed to yield one jot or tittle, but negligent also of opportunities to defend his conclusions. Perhaps he knew it was useless to argue, for, as a Spanish proverb says, "No man is so deaf as he who *will not* hear." Perhaps Perrin and Berthelier, the leaders of the Libertines, too, had fed his brain with false hopes and promises.

The trial was now interrupted through differences between Calvin and the city fathers about municipal affairs. On September 15th Servetus wrote to the council a letter, from which we quote the first paragraph:

"My most Honored Lords: I humbly entreat of you to put an end to these great delays, or to exonerate me of the criminal charge. You must see that Calvin is at his wit's end, and knows not what more to say, but for his pleasure would have me rot here in prison. The lice eat me up alive; my breeches are in rags, and I have no change—no doublet, and but a single shirt in tatters. I have also demanded to have a counsel assigned me. This would have been granted me in my native country; and here I am a stranger, and ignorant of the laws and customs of the land. Yet you have given counsel to my accuser,[1] refusing it to me."

On the 22d of September, perhaps instigated by Berthelier, Servetus took a bold step: he accused Calvin as his calumniator, and asked him to be declared subject to the law of retaliation; but the council took no more notice of this than they had of the previous petition. The appeal to the churches of Switzerland caused another pause in the proceedings, and Michael Servetus, October 10th, forwarded the following letter to the council:

"Most Noble Lords: It is now about three weeks since I petitioned for an audience, and still I have no reply. I entreat you for the love of Jesus Christ not to refuse me that you would grant to a Turk, when I ask for justice at your hands. As to what you may have commanded to be done for me in the way of cleanliness, I have to inform you that nothing has been done, and that I am in a more filthy plight than ever. In addition, I suffer terribly from the cold, and from colic, and my rupture, which causes me miseries of other kinds, I should feel shame in writing about more particularly. It is very cruel that I am neither allowed to speak nor to have my most pressing wants supplied; for the love of God, sirs, in pity or in duty, give orders in my behalf!"

This appeal of the prisoner, as far as his needs were concerned, met with an immediate response; but the audience was never granted. The answers of the Swiss churches arrived at last, and as Calvin had been their inspirer, and they had been taken in concert, they unanimously condemned Servetus's theological views. On the 26th of October the council solemnly assembled and condemned Servetus to be burned alive with his books; the sentence to be carried into effect on the morrow! In a letter to Farel, alluding to the vain attempts made by Perrin, the first syndic, by delay and entreaty, to save the prisoner's life, Calvin speaks of the merciful man by the nickname under

[1] Germain Colladon was introduced as counsel for Nicolas La Fontaine, and continued all through the trial as Calvin's champion.

which he was wont to characterize his great Libertine opponent, and says:

"Our comical Cæsar (Perrin), having feigned illness for three days, mounted the tribune at length, with a view to aid the 'wicked scoundrel' to escape punishment. Nor did he blush to demand that the cause might be remitted to the Council of the Two Hundred. But in vain; all was refused, the prisoner was condemned, and to-morrow he will suffer death."

The sentence was imparted to Servetus in the early morning of the following day—his last. Encouraged by the Libertines, and knowing himself guilty of no intentional blasphemy, he had never thought it possible that he would be condemned to death. He was at first as if struck dumb by the intelligence. He did but groan and sigh, as though his heart would burst, and cry, in his native language, "Misericordia!" Having by degrees recovered self-possession, he requested to see Calvin. Accompanied by two councilors, Calvin entered the prison and asked what he wanted of him. Servetus had the heroic virtue to ask pardon of him—the man who had brought him to his death! Hard to say: the intolerant despot of Geneva, devoid of all humanity, had not a word of mercy for his victim, when a word of his would have saved him!

An hour before noon of October 27, 1553, Servetus was taken from his jail to receive his sentence from my lords the councilors and justices of Geneva. The tribunal, in conformity with custom, assembled before the porch of the Hôtel-de-Ville, and received the prisoner, all standing. The proper officer then proceeded to recapitulate the heads of the process against him, "Michael Servetus, of Villanova, in the kingdom of Aragon, in Spain," in which he is charged—

"First, with having, between twenty-three and twenty-four years ago, caused to be printed at Hagenau, in Germany, a book against the Holy Trinity, full of blasphemies, to the great scandal of the churches of Germany, the book having been condemned by all their doctors, and he, the writer, forced to fly that country. *Item.* With having, in spite of this, not only persisted in his errors and infected many with them, but with having lately had another book clandestinely printed at Vienne, in Dauphiny, filled with the like heresies and execrable blasphemies against the Holy Trinity, the Son of God, the baptism of infants, and other sacred doctrines, the foundation of the Christian religion. *Item.* With having in the said book called all who believe in a Trinity, tritheists, and even atheists, and the Trinity itself a demon or monster having three heads. *Item.* With having blasphemed horribly, and said that Jesus Christ was not the Son of God from all eternity, but only became so from his incarnation; that he is not the son of David according to the flesh, but was created of the substance of God, having received three of his constituent elements from God, and one only from the Virgin Mary, whereby he wickedly proposed to abolish the true and entire humanity of Jesus Christ. *Item.* With declaring the baptism of infants to be sorcery and a diabolical invention. *Item.* With having uttered other blasphemies, with which the book in question is full, all alike against the majesty of God, the Son of God, and the Holy Ghost, to the ruin of many poor souls, betrayed and desolated by such detestable doctrines. *Item.* With having,

full of malice, entitled the said book, though crammed with heresies, against the holy evangelical doctrine, 'Christianismi Restitutio'—'The Restoration of Christianity'—the better to deceive and seduce poor, ignorant folks, poisoning them all the while they fancied they were sitting in the shadow of sound doctrine. *Item.* With attacking our faith by letters as well as by his book, and saying to one of the ministers of this city that our holy evangelical doctrine is a religion without faith, and, indeed, without God, we having a Cerberus with three heads for our God. *Item.* For having perfidiously broken and escaped from the prison of Vienne, where he had been confined because of the wicked and abominable opinions confessed in his book. *Item.* For continuing obstinate in his opinions, not only against the true Christian religion, but as an arrogant innovator and inventor of heresies against popery, which led to his being burned in effigy at Vienne, along with five bales of his books. *Item.* And in addition to all of which, being confined in the jail of this city, he has not ceased maliciously to persist in the aforesaid wicked and detestable errors, attempting to maintain them, with calumnious abuse of all true Christians, faithful followers of the immaculate Christian religion, calling them tritheists, atheists, and sorcerers, in spite of the remonstrances made to him in Germany, as said, and in contempt of the reprehensions and corrections he has received, and the imprisonment he has undergone as well here as elsewhere.

"Now we, the syndics and judges in criminal cases within this city, having reviewed the process carried on before us, at the instance of our lieutenant having charge of such cases, against thee, Michael Servetus, of Villanova, in the kingdom of Aragon, in Spain, whereby guided, and by the voluntary confessions made before us, many times repeated, as well as by thy books produced before us, we decree and determine that thou, Michael Servetus, hast, for a long time, promulgated false and heretical doctrine, and, rejecting all remonstrance and correction, hast maliciously, perversely, and obstinately, continued disseminating and divulging, even by the printing of books, blasphemies against God the Father, the Son, and the Holy Ghost, in a word, against the whole foundations of the Christian religion, thereby seeking to create schism and trouble in the Church of God, many souls, members of which, may have been ruined and lost—horrible and dreadful thing, scandalous and contaminating in thee, thou, having no shame nor horror in setting thyself up in all against the Divine Majesty and the Holy Trinity, and having further taken pains to infect, and given thyself up obstinately to continue infecting, the world with thy heresies and stinking heretical poison—case and crime of heresy grievous and detestable, deserving of severe corporal punishment.

"These and other just causes moving us, desiring to purge the Church of God of such infection, and to cut off from it so rotten a member, we, sitting as a judicial tribunal in the seat of our ancestors, with the entire assent of the General Council of the state, and our fellow-citizens, calling on the name of God to deliver true judgment, having the Holy Scriptures before us, and saying, In the name of the Father, Son, and Holy Ghost, we now pronounce our final sentence, and condemn thee, Michael Servetus, to be bound and taken to Champel, and there bound to a stake, to be burned alive, along with thy books, printed as well as written by thy hand, until thy body be reduced to ashes. So shall thy days end, and thou be made an example to others who would do as thou hast done. And we command you, our lieutenant, to see this our sentence carried forthwith into execution."

The staff, according to custom, was then broken over the prisoner,

and there was silence for a moment. The terrible sentence pronounced, the silence that followed was first broken by Servetus; not to sue for mercy, for he knew there was no appeal, but to entreat that the manner of carrying it out might be commuted for one less dreadful. "He feared," he said, "that, through excess of pain, he might prove faithless to himself, and belie the convictions of his life. If he had erred, it was in ignorance; he was so constituted, mentally and morally, as to desire the glory of God, and had always striven to abide by the teachings of the Scriptures." His appeal to the humanity of the judges, however, met with no response. He prayed God to forgive his enemies and persecutors, and then exclaimed: "O God, save my soul! O Jesus, Son of the Eternal God, have compassion upon me!" From the Hôtel-de-Ville he was taken to Champel. While on the way thither, Farel, the minister who accompanied him, tried to wring from him an avowal of his error, and the prayer, "Jesus, thou Eternal Son of God!" The unhappy Servetus, with a martyr's faith, only replied in broken invocation, "Jesus, thou Son of the Eternal God, have compassion upon me!"

"When he came in sight of the fatal pile, the wretched Servetus prostrated himself on the ground, and for a while was absorbed in prayer. Rising and advancing a few steps, he found himself in the hands of the executioner, by whom he was made to sit on a block, his feet just reaching the ground. His body was then bound to the stake behind him by several turns of an iron chain, while his neck was secured in like manner by the coils of a hempen rope. His two books—the one in manuscript sent to Calvin in confidence six or eight years before for his strictures, and a copy of the one lately printed at Vienne—were then fastened to his waist, and his head was encircled in mockery with a chaplet of straw and green twigs bestrewed with brimstone. The deadly torch was then applied to the fagots and flashed in his face; and the brimstone catching, and the flames rising, wrung from the victim such a cry of anguish as struck terror into the surrounding crowd. After this he was bravely silent; but the wood being purposely green, a long half-hour elapsed before he ceased to show signs of life and suffering. Immediately before giving up the ghost, with a last expiring effort, he cried aloud, 'Jesus, thou Son of the Eternal God, have compassion upon me!' All was then hushed save the crackling of the green wood; and by-and-by there remained no more of what had been Michael Servetus but a charred and blackened trunk, and a handful of ashes."

Thus perished a noble man of whom his age was not worthy—the victim of murderous religious bigotry. But the crime that had been committed shocked the humanity of Geneva, even in that dark period, and, before the year was out, Calvin was driven to self-defense, and displayed the remorseless traits of his character by libeling the man whom he had slain. It is said that, in this persecution unto death, he only manifested the spirit of his age, and must be judged by that standard. While this may be true, it is also happily true that in the lapse of centuries better standards have arisen, by which the character of Calvin will be given over to execration, while that of Servetus will be increasingly honored as that of an heroic Christian martyr.

CORRESPONDENCE.

"THE TIDES."

To the Editor of the Popular Science Monthly.

SIR: Returning a day or two ago to Columbus at the end of our vacation, I last night took up the September number of THE POPULAR SCIENCE MONTHLY. Therein is a letter from Evanston, Illinois, in which some of Prof. Schneider's mistakes, in his article on "The Tides," are pointed out. Two or three years ago Mr. Schneider caused his explanation of the tides to be printed in a little periodical used extensively by Ohio teachers—I refer to *Notes and Queries*, Salem, Ohio. The errors of fact and philosophy were then pointed out in that journal. And, inasmuch as Prof. Carhart has *abundantly* exposed Mr. Schneider's mistakes, I content myself with showing a single point. The whole article on "The tides" is a bundle of absurdities, mistakes of fact and philosophy, and errors of figures in regard to quantity. Mr. Schneider, knowing absolutely nothing of the theory of the tides, as in which there is proof (?) that an inscribed polygon of twelve sides is exactly equal to the circle which contains the polygon—i. e., circumscribes the polygon. Had this new philosophy been put forth in the ordinary newspapers of the day, no notice would have been taken of it. On page 276, July number of THE POPULAR SCIENCE MONTHLY, we find the following: "The earth will then feel a centrifugal force on her side farthest from the moon, and equal to the centripetal force felt on her side facing the moon. These two equal forces, acting in opposite directions," etc. On page 279: "This

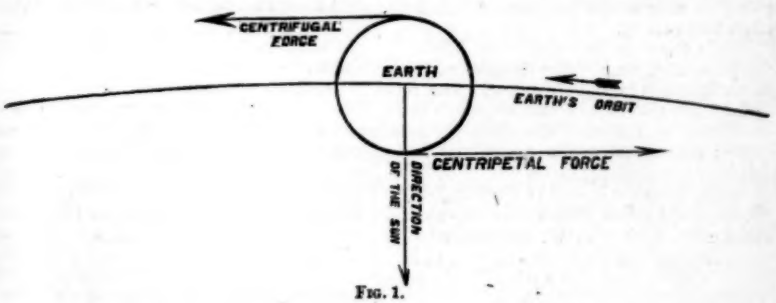

FIG. 1.

force [centrifugal] acts in a line tangent to the earth's orbit." Then the centripetal force must also act parallel to the "tangent to the earth's orbit;" and so, whether you are a mathematician or not, you can easily see that things are going on at loose ends, if they act in this way. (See Fig. 1.) Did you ever elsewhere see, or hear either, of such a centripetal or such a centrifugal force?

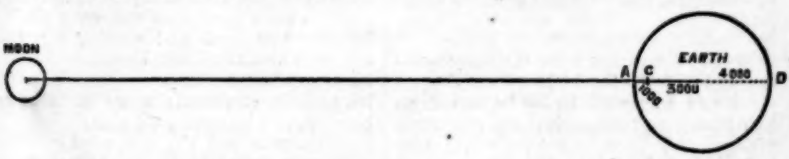

FIG. 2.

understood and explained for the last two hundred years, has concocted a mass of nonsense which is set out as the only rational theory. I incline to the opinion that the New York gentleman who advised you to print the article was playing a practical joke on Mr. Schneider, or else he belongs to that order of city mathematicians who recommended Benson's "Geometry," a work

Again, on page 276: "This large amount of centrifugal force is produced by axial rotation, by revolution round the sun, and by revolution round the centre of gravity [between the earth and the moon] already named."

Let us see: the centrifugal force, in connection with the revolution of the earth on its axis, is *uniform all around the equator*

—consequently it cannot have any part in producing a tide at *one* side of the earth merely. This must be ruled out.

Let us take up the last item of the three. *C* (Fig. 2) is the centre of gravity between the moon and the earth, about 3,000 miles from the earth's centre, and 1,000 from the surface. Now, the centrifugal force is always proportional to the distance from the centre of motion, other things being equal (see any work on mechanics). Then the force at *D* is seven times as great as the force at *A*, for it is seven times as far from *C*. Therefore the tide at *D* will be seven times as high as that at *A*. Do your New York tides play such tricks?

It is also easy to show that the first item of the three has nothing to do with the tides. So in that sentence there are three bald-faced absurdities; and in fact there are about as many such as there are sentences in the whole article. A hundred pages of manuscript are not sufficient to show them all up.

Take the next two sentences following the preceding, viz.: "The direction of these three forces is in the same line. The motion of this part of her surface, which is in this line of direction, is therefore the most rapid; consequently the centrifugal force felt here is also the greatest."

Scan this closely, and you will find what the logicians call a *vicious circle* in the reasoning.

R. W. McFarland,
Professor of Mathematics, etc., Ohio Agricultural and Mechanical College.

Columbus, Ohio, *September* 12, 1877.

THE PRESENT STAGNATION OF TRADE.

To the Editor of the Popular Science Monthly.

The discussion of the present economical problem, the depression of profits and wages, which the article of Prof. Bonamy Price ("One per Cent.") initiated, ought to be continued, and facts and opinions ought freely to be contributed toward a full understanding of the subject.

Prof. Price writes from the money-centre, and reflects the state of enlightened opinion as influenced by his surroundings. The money accumulated there represents savings, and he very naturally and very truly finds fault with our extravagance.

Next comes Mr. Bunce, in the July number ("Over-Consumption or Over-Production?"), giving the views as held in a manufacturing centre; he admits over-production and advises restriction.

This, the distributive (or trade) centre, New York, will not submit to; and Mr. Leland, in the August number, exposes the fallacy of some of Mr. Bunce's reasoning. Without wishing to imply that these writers did not intend to present the question in its total aspect, yet they are viewing it through the glass of their surroundings; and, if I now add the opinion which is held in an agricultural region, the next writer will include this and make his exposition more comprehensive.

We in the agricultural districts deny that there is over-production in our line, or stagnation of trade in our articles. The facts are, that with three very good harvests and several average ones previously, we have not produced more than has been consumed. At the end of June, when the present abundant wheat-harvest was begun, there was not old wheat sufficient for a month's home supply in the Western granary. The new wheat was hurried from the threshing-machine to the mill and ground immediately, to fill the regular orders for the Boston, New York, and Philadelphia markets. Evidently, there has been no over-production in wheat or in corn. We have readily sold all our beef-cattle, our sheep and swine, our wool, fruit, and dairy products. The production of all these has met the demand, and we have realized fair prices.

And, as a natural consequence, there has been no stagnation nor depression in our trade. Our farmers and small town and village mechanics, and our small retail stores, have had all the necessaries of life in abundance, and not a few of the comforts. Mortgages have been lifted, improvements have been made, surplus cash is in all our savings-banks at four per cent. or less interest to the depositors. Our trade centres, doing the honest business of first-hand traffic, are prospering.

All through our country, farms and fisheries have not produced more grain, meat, or wool, than has been consumed from one harvest to another. But we have produced more cotton than can be worn out from one year to another. Our mines have yielded more iron, in many places more coal, than is wanted; much less iron is now required for trades-tools, machinery, and railroading, than at that not far-distant period when a great deal was consumed in building new roads and erecting new machinery where there had been none before. Mines are bringing up more silver than can be usefully employed; hence it is being hoarded, and its price must sink.

The cotton and the iron are forced upon the converting trades, in which so many mill-hands and factory-operatives are employed. The raw material in excess becomes cheaper. The converted products, the articles manufactured for consumption, are in excess, and, forcing themselves upon the market, reduce prices, as well their own as the price of the labor that produced and distributed them. And, as a last consequence, these products are glutting the shelves of the merchants' warerooms, diminishing the profits of the carrier and

merchant to a trifle, and ending in bankruptcy and strikes.

If all our cotton-mills and their dependencies, all our iron industries, and some others, were to suspend, we should not exhaust the supply on hand of their fabrics for quite a number of years.

To sum up—

1. There is no over-production of grain and meat.

2. There is a great surplus of textile, iron, and similar fabrics.

Hence, there is a one-sided over-production, a one-sided depression of prices for labor and for fabrics; and, on the other side, a normal prosperity and attending accumulation of savings.

The problem for relief at once presents itself in the question whether a change of occupation of a considerable number of factory-operatives, mechanics, and forwarders, from the trades to agriculture, would afford the remedy and reëstablish the equilibrium.

The farmer, even at the most Western frontier, has always a sufficiency of food raised by himself, and generally a surplus, adequate for furnishing his family some comforts, and always independence.

If a large majority of the weavers and machine-workers of to-day were to become agriculturists, they would become consumers instead of producers of the very articles which are now made in excess; and, while the price of the articles might not be advanced, those that made them would have full and steady, instead of interrupted and uncertain, employment—a double gain on the present disturbed state.

No legislative or government interference is needed or desirable. The adjustment of the disturbed equilibrium in the productions will work itself out as soon as the true causes of the "stagnation in trade" are clearly understood.

A case in point will illustrate. In a small county town, the trade-centre of a good farming district, the retail stores had done a very profitable business up to about 1874. As a natural consequence, many persons with a small capital had engaged in this line; finally their sales diminished, profits declined, because their number had increased beyond the former ratio between stores and customers. A few of them looked about for other occupations. One engaged in tanning, which was a good field; another started a custom grist-mill, for which there was a demand; another opened a pork-packing establishment; another went into farming on a large scale. Here, the overcrowding with its attendant evils was understood as the cause of the decline in trade; the enterprising members of the profession left it for occupations that pay better, and the equilibrium has been reëstablished.

All efforts at relief from the dull times must lie in the same direction. A large number of our mill-hands and factory-operatives must take to farming, must raise themselves the food for their families, and some to exchange for comforts which their fields and herds cannot directly give.

The old mill-hands ought not to attempt the change; but the young and middle-aged ought, and escape from their "bondage" in the East to the free fields of our wide Western country.

F. A. Nitchy.

Jefferson City, Missouri.

THE GREAT RAILROAD-STRIKE OF 1877.

To the Editor of the Popular Science Monthly.

The loss from peculation in the management of railways has probably been exaggerated; these important institutions have, in the main, been conducted on business principles, with an eye to dividends. Those in control have aimed—with success, until recently—to secure competent and willing aid, and the *esprit de corps* so essential in great enterprises. But managers and men are alike the victims of a train of circumstances foreseen only by a few political economists. The plain fact is, that the railroad system finds itself in the brunt of a movement that has been long approaching culmination. Multitudes of our native youth, seduced by the supposed attractions and opportunities of the city, and swarms of the poorer immigrants, have precipitated the catastrophe, by swelling the already overcrowded centres of population—have added to the number to be fed, by decimating the army of producers—have lowered the price of labor, by increasing the number of applicants. Reduction of extravagant salaries and other "leaks" is to be commended, but will not, it is to be feared, effect any material increase of wages for a long time to come, and that from no indisposition on the part of managers, but from *causes beyond their control*.

Populations have been passing through the throes of greater social transitions than were ever before crowded into a century, and a vast amount of inconvenience was and is inevitable. The immense industries created by labor-saving machinery have, in not a few instances, outrun the present demand, and hence—too often—an advancing throng of aspirants has found itself confronted with another throng in disorderly retreat: the result is a fierce struggle for existence, in which reason exercises but a feeble sway.

Nature and Providence are inexorable, and take no thought for the individual intruder in their *track*. These forces are now apparently engaged in starving the surplus humanity back into the cornfields.

But he is a sorry physician who is content with a diagnosis of the disease, and prescribes no preventive, or even remedy; and as in the corporeal body, so in the body corporate—the best remedy is that which operates through natural forces: let us see if such cannot be made available. Cannot this drift cityward be checked, or even turned backward, by rendering farm-life more attractive to young men? For example:

Instead of isolated homesteads, often miles asunder, why not dedicate a central space for a good, old-fashioned Saxon "common," which might hold the school, the church, the park, and other amenities of civilization, and be surrounded by the dwellings of the settlement? And why cannot parents, instead of placing their sons in dusty city offices, or behind ignoble counters, enable these young men—with the aid of competent experts, where necessary—to establish such settlements? Might not education in such a community, by embracing the study of natural objects, applied science, and the practice of handicrafts, convert material that now evolves into boors, "hoodlums," or "counter-hoppers," into interested (because intelligent) and occupied producers, for whom rural life and scenes would possess attractions superior to the vulgar dissipations of the faubourg and the feverish competitions of trade?

G. H. KNIGHT.

CINCINNATI, *August* 10, 1877.

EDITOR'S TABLE.

NARROWNESS AMONG MEN OF SCIENCE.

IT is a great mistake to suppose that all the influences exerted on the mind by scientific study are necessarily of a widening or liberalizing character. There is an immense amount of legitimate scientific work that does not tend to produce any such effect, but, on the contrary, has a narrowing and cramping influence upon the intellect. The intense and prolonged concentration of thought upon special inquiries, when it becomes a habit, excludes that breadth of view which can only be attained by contemplating subjects in their wide relations. Absorption in detail is inevitably unfavorable to the grasp of principles, so that the mere specialist is never a philosopher. Of course, all strong scientific men must be more or less specialists, must limit themselves to restricted portions of the scientific field; but in such minds the narrowing influences of particular studies are counteracted by keeping up an interest in various subjects, and the comprehensive results of research. There are many scientific workers, however, who fail to do this, who lose themselves in their own narrow departments, and become, not only inappreciative of the grand connections of scientific truth, but contemptuous of the higher work of scientific generalization. They applaud observation and experiment, and the accumulation of isolated facts, and stigmatize as mere theorizers those who labor to organize these facts and observations into rational systems. It is not to be expected, nor is it desirable, that all scientific workers should be philosophical thinkers, but there is great need that many of them should cultivate a more liberal spirit in this respect, and recognize that the systematic study of the relations of the sciences is as much a legitimate specialty as the working out of their separate and disconnected facts.

There is another respect in which a large class of scientific men exhibit a narrowness of feeling that is far from commendable. They cherish but little sympathy with the work of diffusing science, and take frequent occasion to disparage the motives and character of those of their brethren who devote themselves to this kind of labor. We are glad to notice that the *Saturday Review* administers a just rebuke to these illiberal and censorious gentlemen. Commenting upon President Thomson's address before the British Association, that journal remarks:

"It is a thankless office to have to re-

cord, as we are now compelled to do, that this time the impression was not a very favorable one. In one word, the president's discourse was much too technical for the occasion and the audience. It would be ungenerous to cast any personal responsibility for this result on the eminent specialist who was chosen for the office. The gift of interpreting the results of highly-special researches for the benefit of those who are not prepared beforehand by special knowledge is by no means a common one—in fact, it is itself a specialty which very few have mastered; for which reason people who are anxious to parade themselves as amateurs in science are much in the habit of cheapening it. The notion that Prof. Huxley and Prof. Tyndall are mere popularizers—because, forsooth, they can expound as well as discover—has almost attained the rank of a vulgar error. Some remarks to that effect were heard at this very meeting in the Guildhall of Plymouth. Those who imagine that such remarks give them a scientific air may be assured that there is no more certain stamp of a narrow and superficial habit of mind. However, we cannot all go to Corinth; a specialist, however eminent, has not necessarily the gift of large and lucid exposition, and if he has not, the temptation to take refuge in the technical details of his own province is almost irresistible."

The pettiness and jealousy here reprobated is by no means confined to England; it has become a sort of cant among many reputable scientific men in the United States. The contemptuous remarks often made of the efforts of such men as Huxley and Tyndall to make science acceptable to the public are not always inspired by envy; they betray a very low estimate, often tinged with scorn, of all efforts to reduce science to a form acceptable to common people. We have had occasion repeatedly to call attention to the paradox that, in this country, eminent for its popular institutions and its popular education, scientific men are in less hearty sympathy with the work of popularizing scientific education than they are in England. The American Scientific Association has persistently declined to take any interest in the question, while the British Association, upon which it was modeled, has done much to encourage and promote this kind of effort. Although our teachers and boards of education have often and urgently called for assistance in organizing courses of study in which science should receive increasing attention, and be more methodically and efficiently cultivated, we are not aware that any authoritative body of American scientists has ever troubled itself to offer advice or respond to such appeals.

There is, of course, a certain validity in the reply that scientific bodies are organized for other purposes, and that, as Agassiz used to put it, "it is their office to create science, and not to distribute it—the latter function being the office of our educational system." But if our system fail of its duty in this particular, it is certainly incumbent on those influential bodies, who have the interests of science in charge, to exert such an influence upon the schools as shall tend to secure the object, and, failing to do this, they are chargeable with a culpable indifference toward the work of making science common and popular. The plea that scientific men are absorbed in investigations, and have little time to give to these outside considerations, is quite sufficient to excuse a simple non-participation in such work; but there is abundant reason to think that the plea is often an uncandid pretext, and that the disinclination to act is due to narrow and petty prejudices upon the subject.

The indifference of many scientific men to the work of popularizing science, and their ill-concealed disdain of those who succeed in it, are no doubt largely due to their incapacity to share in it. We have, unfortunately, but few scientific men with sufficient literary training to write with elegance or lecture with eloquence upon topics which they may nevertheless thoroughly understand, and the number of scientific professors who fail in exposition before the public, and even before their col-

lege classes, is unfortunately large. The art of vivid, effective presentation by language is so difficult that, unless a man has a genius in this way, it requires great labor to attain even a moderate excellence in it, and when attained there is no doubt a presumption that it is at the expense of more solid things. Yet there is no reason why men of real science should not be able to arrive at much greater proficiency as literary artists than is customary with them, if they would cultivate more liberal views of the importance of popular work. At all events, if our scientific men will not be at the pains to train themselves in the art of attractive popular exposition, and will be content to write and speak in the bald, technical, involved, and repulsive style which is so common with many, let them not reproach others for setting a higher value upon the accomplishments of the successful public teacher.

We have spoken in the foregoing article of the propensity of certain scientific men to magnify facts and depreciate theories. This is not only an evidence of narrowness, but of ignorance, for facts are of no value without theories. They are good for nothing until explained, or brought by reason into relation with other facts, so that some step is taken toward the establishment of a law. It is this connection of science with methods of thought, and its value as a means of arriving at the best methods, that give it its claim upon the attention of all intelligent men. The demand for its popular recognition, and its prominent place in education, rests far less upon its service in the grosser utilities of life than on its influence upon the higher intellectual operations. Science being tested and verified, clearly reasoned and demonstrated truth just to the degree in which it is matured, it must stand in the most intimate relations with those logical processes which have for their object the establishment of truth. Logic, of course, grew up into a system before the sciences were developed; but it was a partial and imperfect logic. Following the modern developments of science, growing out of them, and seriously influenced by all their great steps of advance, we have a body of logical and philosophical disquisitions that are presented by such men as Herschel, Whewell, Mill, and Jevons, who deal with the mental operations involved in the investigation of truth, in the full light of modern scientific experience. Yet this interesting field of thought must be regarded as only fairly opened, and the works of the eminent gentlemen referred to, though permanently valuable, are no doubt much in the nature of preliminary inquiries, to be yet carried out more thoroughly, and reduced to greater unity and harmony. Impressed with the importance of this great phase of the intellectual work of the age, which it is one of the leading objects of The Popular Science Monthly to promote, it has been our good-fortune to secure the services of an independent thinker and able writer, who will contribute to our pages a series of articles under the general title of "Illustrations of the Logic of Science." The author has already attained an honorable eminence in the world of science by the promulgation of advanced views of logical method, and he will reduce these views to a more systematic and popular form in the papers now to be published. We call attention to the first essay of this series in the present number, which, though but introductory, may be taken as foreshadowing the interest of the discussions that are to follow.

It will hardly be necessary to invite the reader's attention to an article, to be also followed by others, on "The Growth of the Steam-Engine." That

revolutionary machine, which is so intimately interwoven with the development of civilization, is itself a part of that development, and as much a product of evolution as an oak a thousand years old. The interesting story of its unfolding from early germs, through long and laborious experiments, to the complete integration of the mechanism, will be told by Prof. Thurston in successive papers, which will be freely and elegantly illustrated. The accompanying "portrait-gallery" of the great inventors who have contributed to this grand mechanical achievement will be the finest and fullest afforded by the historic literature of the subject.

LITERARY NOTICES.

THE HOLY ROMAN EMPIRE. By JAMES BRYCE, D. C. L., Regius Professor of Civil Law in the University of Oxford. 12mo. Pp. 479. New York: Macmillan & Co. 1877. Price, $2.

THE Holy Roman Empire dates from the year 800 A. D, when a king of the Franks was crowned Emperor of the Romans by Leo III.; and it is on the inner nature of this empire, as the most signal instance of the fusion of Roman and Teutonic elements in modern civilization, that the author dwells, treating of the influence which it exercised over the minds of men, and the causes that gave it power; speaking less of events than of principles, and describing the empire, not as a state, but as an institution created by and embodying a wonderful system of ideas. The forms which the empire took, in the several stages of its growth, are briefly sketched. A glance is taken at the condition of the Roman world in the third and fourth centuries, in order to make clear out of what elements the imperial system was formed.

Expiring antiquity had bequeathed to the ages that followed two great ideas—a world-monarchy and a world-religion. The Roman dominion, giving to many nations a common speech and law, broke down the differences of race and nationality—when foreigner and enemy were synonymous terms—and made citizens of them irrespective of their religious beliefs, which were purely local and national. For these, Christianity substituted the belief in one God, and the doctrine of the unity of God enforced the unity of man; and there was thus formed a community of the faithful—a holy empire—designed to gather all men into its bosom. Thus the Holy Roman Church and the Holy Roman Empire were one and the same thing in two aspects. As divine and eternal, its head was the pope, to whom souls were intrusted; as human and temporal, the emperor, commissioned to rule over men's bodies and acts.

Chapters are devoted to the subjects "Imperial Titles and Pretensions;" "Changes in the Germanic Constitution;" "The Empire as an International Power;" "The City of Rome in the Middle Ages;" "Effects of the Renaissance and Reformation on the Empire;" its last phases and end in 1806 by the abdication of Francis II., 1,006 years after Leo the pope had crowned the Frankish king. A supplementary chapter is added on "The New Germanic Empire," and an appendix of notes on "Imperial Titles and Ceremonies." To the whole is prefixed a "Chronological Table of Emperors and Popes," and "Dates of Important Events in the History of the Empire."

The treatment and style of the work are judicial and scholarly, and the book will doubtless be a standard one on the subjects of which it speaks. It has been remarkably well received on all sides, having already passed through seven editions.

THE PHYSIOLOGY OF MIND. Being the First Part of a Third Edition, revised, enlarged, and in great part rewritten, of "The Physiology and Pathology of Mind." By HENRY MAUDSLEY, M. D. Pp. 547. New York: D. Appleton & Co. 1877. Price, $2.

TEN years ago, Dr. Maudsley issued a large, well-elaborated volume under the title of "The Physiology and Pathology of Mind." It was well received, and a second edition was called for, which has been now for some time out of print. After several years' further study of the subject, and availing himself of the great activity of investigation in this branch during the last decade, Dr. Maudsley has revised his work, and so extended it that it became desirable

to make it into two volumes instead of one. That which was the first part now appears as a separate volume, confined to the physiology of mind; and will be followed by its sequel, or companion-work, as a separate treatise on mental pathology. It is an excellent thing on every account to divide the original work in this way, for, although the subjects are most intimately connected, they can be just as well studied together now as before, while there will unquestionably be many who will care chiefly for but one of the volumes. That now issued has an interest for all students of the philosophy of mind, while the one following will more directly concern the medical profession. "The Physiology of Mind" by Dr. Maudsley is a very engaging volume to read, as it is a fresh and vigorous statement of the doctrines of a growing scientific school on a subject of transcendent moment, and, besides many new facts and important views brought out in the text, is enriched by instructive notes and quotations from authoritative writers upon physiology and psychology, and by illustrative cases which add materially to the interest of the book. We have room for but one of these, showing the manner in which the loss of one sense is followed by an extension or increase of function of those which remain:

"Many years ago application was made to Dr. Howe, of the Massachusetts Asylum for the Blind, by a locksmith for the 'loan' of a blind boy, as he said, who had quick ears and a silent mouth. On giving satisfactory answers he got his loan. He wanted a boy to help him open a new and complicated lock. An inventor exhibited a locked safe and the key, saying that there was money within, which should be given to whoever could open the lock without deranging it. The peculiarity of the lock was, that it had ten bolts, which, from all that could be ascertained, seemed exactly alike, but in reality one of them was an inch longer than the others, so that, when all were thrown forward, that one alone held the door closed. The key would lift any of the ten bolts; but in order to open the safe it must be applied to the long bolt, and to that only, and that one must be lifted and turned back in order to open the lock; but if any other of the ten were lifted and turned back ever so little, it deranged the combination, and the lock could only be opened by a peculiar instrument. The object, then, was to ascertain which of the ten was thrown forward without turning back any other one.

"The mechanic lifted each bolt carefully with the key, and let it fall, but without trying to throw it back; and he then tried to ascertain if in falling it made any peculiar noise; for he inferred that, as the only one which held the door was an inch longer than the others, it must fall with a slightly greater force; but the difference was too slight for his ear. He took the blind lad, and asked him to listen carefully to the sound which each bolt made as he lifted and let it fall. After listening to each intently, the lad said the sixth one struck a little the loudest. The mechanic lifted and let each one fall carefully several times, and each time the boy insisted that the sixth bolt sounded the loudest. Upon this the mechanic lifted and turned back the sixth, and the lock was opened without the combination being deranged."

No library of mental philosophy will be complete without this book, and no liberal student of the subject can refrain from giving it his serious and critical attention.

A PRACTICAL TREATISE ON LIGHTNING-PROTECTION. By HENRY W. SPANG. 12mo. Pp. 180. With Illustrations. Philadelphia: Claxton, Remsen & Haffelfinger. 1877. Price, $1.50.

THE above book contains the result of the author's observation and study on the subject of lightning-protection during an eighteen years' experience in the telegraph-business. After an introductory course of experiment with artificial lightning, and an explanation of the principal known facts relating to the electricity of the earth and atmosphere, the author proceeds to show that few of the lightning-rods or conductors now erected can be relied upon for an easy passage of heavy lightning-discharges, and goes on to prove that the metal roof and rain-pipes of a building can be made a better protection at a reduced expense. Explicit directions then follow for the protection of buildings of every description, ships, oil-tanks, steam-boilers, bridges, telegraph-poles, etc.

NOTES UPON THE LITHOLOGY OF THE ADIRONDACKS. By ALBERT R. LEEDS. Pp. 35. From the *American Chemist*.

PROF. LEEDS does not assume to present a complete lithology of the Adirondack region, but limits himself to giving an outline of the work already done in that field: a description of the rocks so far collected by himself; analyses of some of the more important typical rocks and minerals; results of microscopic study of rock-sections; and, finally, inferences drawn from these premises.

JAHRES-BERICHT DES NATURHISTORISCHEN VEREINS VON WISCONSIN. 1876–'77. Milwaukee: C. Dörflinger, printer.

THIS Annual Report of the Natural History Association of Wisconsin shows a gratifying increase in the number of members, and in the specimens contained in the various cabinets of natural history. The association embraces a section for zoölogy, one each for botany, mineralogy, geology, and ethnology, and the cabinets of each of these sections received during the year a large number of additional specimens. The list of active members embraces over 200 names.

RELATIVE AGES OF THE SUN AND CERTAIN OF THE FIXED STARS. By Prof. D. KIRKWOOD. Pp. 4.

FROM the facts considered in this essay by Prof. Kirkwood, it appears to follow that —1. The solar system has not existed over twenty or thirty million years; 2. That our solar system is more advanced in its physical history than the larger component of the double star Alpha Centauri; 3. That 61 Cygni has reached a greater degree of condensation than the sun; and, 4. The companion of Sirius has reached a greater state of maturity than the sun, while the contrary seems to be true in regard to the principal star.

THE LOCUST-PLAGUE IN THE UNITED STATES. By C. V. RILEY, M. A., Ph. D. Pp. 236. With numerous Illustrations and Colored Maps. Chicago: Rand, McNally & Co. Price, $1.25.

WE have here the fruit of the author's long-continued studies of the haunts and habits of the Rocky Mountain locust, as published from time to time in the "Entomological Reports of Missouri" and in sundry periodicals. The subject of the book is one that possesses a lively interest for farmers over a wide area of our Western States and Territories. Prof. Riley's object in publishing in a separate volume all the information he has been able to acquire with regard to the Rocky Mountain locust is a practical one,—namely, to acquaint the farmer with the means of counteracting this plague—hence he, as far as possible, avoids technicalities, and writes in a style easily intelligible to the popular mind.

COMPENDIUM OF FACTS AND EVENTS. Compiled by E. EMERY. Pp. 496. Peoria, Ill.: *Transcript* print. Price, $3.

THIS very convenient volume represents an enormous expenditure of labor in collecting statistical information in regard to "almost everything of interest to man." The matter is gathered in every instance from the most authentic sources, and is presented to the reader in the smallest possible compass. The work is one of permanent value. It is full of useful information for men in every walk of life, as the farmer, the mechanic, the merchant, the publicist, the schoolmaster, the man of letters, etc.

PETERS'S GENERAL HISTORY OF CONNECTICUT. Edited by SAMUEL JARVIS MCCORMICK. Pp. 285. New York: D. Appleton & Co. Price, $1.50.

IT was in this volume that publication was first made to the outside world of the so-called "Blue-Laws" of Connecticut. Of these laws the author says that they were "never suffered to be printed." He does not profess to do more than to give "a sketch" of some of them, so as to exhibit the spirit which pervades the whole. What that spirit was can be seen from a few of the prohibitions of the code, for instance: "No one shall run on the Sabbath-day, or walk in his garden or elsewhere, except reverently to and from meeting. No woman shall kiss her child on the Sabbath or fasting-day. No one shall read common-prayer, keep Christmas or Saints-days, make minced-pies, dance, play cards, or play on any instrument of music, except the drum, trumpet, and Jew's-harp. No food or lodging shall be afforded to a Quaker, Adamite, or other heretic." The authenticity of these laws has been called in question, and recently Mr. J. H. Trumbull published a work designed to show that the "False Blue-Laws" were invented by Dr. Peters. The object of the editor in republishing the work is to make the public acquainted with the side of the question opposed to that of Mr. Trumbull, and to confirm, as far as possible, by contemporary testimony, the truthfulness of Dr. Peters's summary of the Puritanic legislation of Connecticut and New Haven. But, quite apart from this question, the work is one of real value, and well worthy the honor of republication.

WEIGHING AND MEASURING. By H. W. CHISHOLM. Pp. 192. London: Macmillan. Price, $1.50.

THE author of this little treatise, after defining weight and measure, devotes a chapter to "Ancient Standards of Weight and Measure," in which it is shown that accurate standards were totally unknown to the ancients, and in particular that the standards of ancient Egypt were *not* based on the earth's dimensions. The history of English standard units of weights and measures is then given with considerable minuteness; next follows a chapter on the metric system; finally, there is a chaper on "Weighing and Measuring Instruments, and their Scientific Use."

THE BIBLE OF HUMANITY. By JULES MICHELET. Translated by VINCENZO CALVA. New York: J. W. Bouton. Pp. 347. Price, $3.

THIS book is not, as might be inferred from its title, a scripture which would be acceptable to the followers of Comte, nor would it answer as a foundation on which to build any creed. It is one of a class—compilations of moral, religious, and ethical teachings from various sources, with comments and extensions by the compiler, and bearing the impress of his ideas, which in the case of M. Michelet are quite peculiar. It is rather more reverent and refined than John Stewart's "Bible of Nature," but it is an equally great misuse of words to call it a Bible.

The literature and art of India, Persia, and Greece, "the three hearths of light," and of Egypt, "the monument of death," have inspired the greater part of the work. Of course, it is erotic; the commentary on the "Song of Songs," though rather free, presents that drama in a wonderfully bold and vivid way; and Chapters VI., VII., and VIII., which treat of woman, are marked by the unhealthy exaltation which appears in all of Michelet's later works, seeming, as the writer of the biographical sketch says, "to have been written under the influence of an uninterrupted honey-moon."

It aims to be epigrammatic, abounds in italics and exclamation-points, and offers a rich field for phrase-hunters. It is among these and rather sentimental transcendentalists that the book will find its readers.

LECTURES AND ESSAYS. By VIRGIL W. BLANCHARD, M. D. New York: Blanchard Food-Cure Company. Pp. 67. Price, 10 cents.

THESE so-called essays are papers ostensibly on physiological subjects, but are really written to puff a lot of preparations sold by the author, who styles himself the "originator of the food-cure system." They are written in the style which characterizes that class of literature—various diseases are described, embellished with sensational horrors, which may be avoided and cured by the use of the food-remedies. While Pavy, Frankland, and other able investigators, are becoming more and more wary in their statements as to the way in which food is assimilated, and are beginning to question positions that have heretofore been generally accepted, Dr. Blanchard dogmatically asserts his ability to furnish specific material which shall go directly to the defective spot in the system, and set about the work of repairing the wasted tissues and disorganized nerve and brain cells without delay.

It is probably useless to expose the fallacies of this sort of trash; so long as people are content to remain in ignorance of hygienic rules, and ignore the laws of waste and supply, the platitudes of these venders will have readers, and their nostrums find sale.

A PARTIAL SYNOPSIS OF THE FISHES OF UPPER GEORGIA: WITH SUPPLEMENTARY PAPERS ON FISHES OF TENNESSEE, KENTUCKY, AND INDIANA. By DAVID STAR JORDAN, M. D. Salem, Mass. Pp. 70.

IN a recent notice of Commissioner Baird's Report on Food Fishes, we expressed a hope that a systematic list of the fishes of American waters, with descriptions, and an account of habitat, seasons, etc., would some time be made.

The papers included in the pamphlet before us are valuable contributions to such a work. Over the area indicated in the title the fishes have been catalogued and described with scientific accuracy, the localities, relative abundance, and common names, are given, while the synonyms of their nomenclature receive due attention. No attempt is made to give any account of the seasons, habits, or manner of breeding,

which would be of most interest to the lay reader; but this would, perhaps, be too much to expect of the scientific worker attempting to cover so much ground.

THE METALLURGICAL REVIEW. Vol. I., No. 1, September. Published monthly by DAVID WILLIAMS, 83 Reade Street, New York. Price, $5 per year. Single copy, 50 cents.

THE projectors of this periodical are of the opinion that the metallurgical industries have become sufficiently important to have a current literature of their own, and intend that this *Review* shall be a vehicle for discussions on purely scientific topics, which are too abstruse for newspapers, and are given to the public but slowly through the medium of books.

This first number gives promise that the publication will have an immediate and permanent value. It contains, among others, essays on the "Mechanical Treatment of Metals," by Prof. R. H. Thurston; "Studies of Elemental Iron, and its Modifications," by Prof. Henry Wurtz; "New Iron District of Ohio," by E. C. Pechin; and a miscellany of short articles of metallurgical interest. It is finely printed in large, clear type, on excellent paper, with ample margins, presenting a most creditable appearance.

PUBLICATIONS RECEIVED.

Publishers' Trade List Annual (1877). New York: *Publishers' Weekly* print. Price, $1.50.

Free-Thinking and Plain Speaking. By Leslie Stephen. New York: Putnam's Sons. Pp. 322. Price, $2.50.

Volumetric Analysis. By Dr. Emil Fleischer. London and New York: Macmillan & Co. Pp. 294. Price, $2.50.

Method of Least Squares. By M. Merriman. Same publishers. Pp. 207. Price, $2.50.

Egypt as it is. By J. C. McCoan. New York: Holt & Co. Pp. 226. With Map. Price, $3.75.

Engineering Construction. By J. E. Shields, C. E. New York: Van Nostrand. Pp. 138. Price, $1.50.

Guide to Ridge Hill Farms. Boston: Getchell Brothers print. Pp. 156.

The Complete Preacher. Also, *The Metropolitan Pulpit*. Monthly. New York: Religious Newspaper Agency. $2 per year.

Spiritual Sciences; Revelation of God; Christmas and New-Year's-Day; Good Friday; Biblical Theology; Ascension-Day and Whitsuntide. All by "Kuklos." London: Published by John Harris, Kilburn Square.

Fur-bearing Animals. By Elliott Coues. Washington: Government Printing-Office. Pp. 348. With Plates.

Weather Reports for May, 1874. Washington: Government Printing-Office. Pp. 190.

The Hidatsa Indians. By W. Matthews. Washington: Government Printing-Office. Pp. 246.

Geological and Geographical Survey of Colorado and Adjacent Territory (1875). By F. V. Hayden. Washington: Government Printing-Office. Pp. 834. With Maps and Plates.

Contributions to North American Ethnology. By W. H. Dall and George Gibbs (Powell's Survey of the Territories). Washington: Government Printing-Office. Pp. 361. With Plates.

The Geyser Basins of the Yellowstone Park. By I. B. Comstock. From the "Proceedings of the American Association." Pp. 8.

Results of Hypertrophied Tonsils. By A. W. Calhoun, M. D. Atlanta: Dickson print. Pp. 12.

Canadian Reciprocity. Pp. 16. Also, The Hard Times. Pp. 12. Philadelphia: American Iron and Steel Association.

Proceedings of the American Public Health Association. New York: Hurd & Houghton. Pp. 249. Price, $4.

Positivist Prayer. By J. Lonchampt. Goshen, N. Y.: *Independent Republican* print. Pp. 32.

Civilization and the Duration of Life. By C. T. Lewis. Cambridge: The Riverside Press. Pp. 11.

Anthropoidea. Pp. 8. Sketch of Cuvier. Pp. 8. Hunterian Oration. Pp. 7. By Dr. A. J. Howe, of Cincinnati.

Bulletin of the Survey of the Territories (Hayden's). Vol. III., No. 4. Washington: Government Printing-Office. Pp. 120.

Bulletin of the United States National Museum, Nos. 7, 8, and 9. Washington: Government Printing-Office.

Report of New York Meteorological Observatory (1876). New York: Brown print. Pp. 105. With Charts.

Organic Acids in Examination of Minerals. By H. C. Bolton. New York: Gregory Bros. print. Pp. 36. With Plate.

Fifteen-Cent Dinners. By Juliet Corson. New York: Published for gratuitous distribution. Pp. 39.

The Kindergarten Messenger. Vol. I., Nos. 9 and 10. Price, $1 per year.

Both's Method for treating Tubercular Consumption. New York: Cherouny & Kienle print. Pp. 20.

POPULAR MISCELLANY.

"A New Type of Steam-Engine."—Prof. R. H. Thurston read a paper at the Nashville meeting of the American Association on "A New Type of Steam-Engine," a report of which we find in the *American Manufacturer*. The author first gave a history of the steam-engine from Hero's time; then he discussed the modern type of steam-engine, pointing out its shortcomings; finally he proposed a new type, designed to prevent loss of heat-energy. There are, he observed, only two possible methods of utilizing the full heat-energy: the first is by enormous expansion, cooling the steam till it is all condensed into water and till all the heat is even taken out of that water,

but this he shows to be impracticable; the other method is to use part of the power of the engine to pump back the discharged steam, containing as it does some water condensed from the steam, into the boiler. This latter method is theoretically practical, and the purely mechanical difficulties in the way of its realization are by no means insuperable.

As the steam in the cylinder of an engine expands, *doing work*, part of it condenses. The difference between the heat-energy of the steam at the beginning of the stroke, and that of the steam and water at the end of the stroke, is equal to the heat-equivalent of the mechanical work done by the steam. The change of mechanical condition which the steam undergoes during the stroke—namely, its conversion into water—renders it possible that the mingled steam and water remaining in the cylinder at the end of the stroke may be forced back into the boiler with a less expenditure of mechanical energy than the steam gave out during the stroke.

The Telephone anticipated.—As is the case with all great inventions, the telephone is now said to be nothing new; its principle was known long ago, and even exemplified in practice. Many are the claimants of priority in solving the problem of the transmission of articulate sound to great distances, but we know of none whose case is stronger than that of "Monsieur Ch. B——," who appears to have solved the problem as early as 1857. In the Count du Moncel's "Exposé des Applications de l'Électricité," published twenty years ago, occurs the following passage (translated in *Nature*):

"After the marvelous telegraphs which are able to reproduce at a distance writing of this or that individual, and designs more or less complicated, it seemed impossible, said M. B——, to advance further in the regions of the marvelous. Nevertheless, essaying to do something more, I asked, for example, if speech itself would not be capable of transmission by electricity; in a word, if one would not be able to speak at Vienna and be heard at Paris. The thing is practicable. This is how: Sounds, it is known, are formed by vibrations and carried to the ear by these same vibrations, which are reproduced by the intermediate media. But the intensity of these vibrations diminishes very rapidly with the distance, from which it follows, even in the employment of speaking-trumpets, tubes, and of acoustical horns, the limits which cannot be surpassed are very restricted. *Imagine that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice; that this plate establishes and interrupts successively the communication with a battery. You would be able to have at a distance another plate which would execute at the same time the same vibrations. It is true that the intensity of the sounds produced would be variable at the point of departure, where the plate is vibrated by the voice, and constant at the point of arrival, where it is vibrated by electricity.* But it is demonstrable that this would not alter the sounds. . . . In any case, it is impossible to demonstrate that the electric transmission of sounds is impossible. . . . An electric battery, two vibrating plates, and a metallic wire, will suffice."

The Slaves of Ants.—The subjugation of other insects by various species of ants is a familiar fact of natural history; it is less usual to see two or more species thus subjugated. Prof. Leidy, in some remarks made at a meeting of the Academy of Natural Science of Philadelphia, recounts his observations on a colony of yellow ants (*Formica flava*), which had three different insects in their service, namely, a species of *Aphis*, a *Coccus*, and the larva of an insect, probably coleopterous. The aphides, he tells us, were kept in two separate herds, and these were separated from a herd of cocci. The larva was in the midst of one of the former herds. In another and larger colony of yellow ants there was a herd of aphides which occupied the under-part of one margin of the stone under which the ants had their nest; the surface occupied by these aphides was about ten inches long and three-fourths of an inch broad. The same colony also possessed a separate herd of cocci, closely crowded, and occupying almost a square inch of space. Both aphides and cocci, with few exceptions, adhered to the under-surface of the stone, and were not attached to the roots. They appeared to be carefully attended by the ants, which surrounded them. The larva, too, was carefully attended by the ants, which were frequently observed to stroke it with their antennæ. The aphides and cocci were all in good condition, but without visible means of subsistence, excepting the neighboring grass-roots partially extending into the earth beneath the stones, to which they probably were at times transferred by their masters.

Obituary.—We have to record the death of the astronomer Leverrier, which took place at Paris on September 23d. Leverrier was born in 1811. Early in life he evinced great aptitude for chemical research, but his natural bent lay rather in the direction of the mathematical sciences. On being appointed to a position in the Polytechnic School, he devoted himself with great ardor to the study of the great problems of speculative astronomy, and soon earned high distinction by sundry memoirs. He was elected member of the Paris Academy of Sciences in 1846, and during the same year he made the great astronomical discovery of his life —that of the planet Neptune. In 1849 he entered political life as a deputy in the Legislative Assembly; under the Empire he was a senator, and for some time Inspector-General of Public Instruction. In 1853 he was appointed Director of the Paris Observatory, and so continued till 1870, when he resigned. He was reappointed in 1872, and held the position till his death. That sad event was no doubt hastened by the effects of mental overwork in his search for an intra-Mercurial planet.

The death is announced of J. P. Gassiot, F. R. S., in the eightieth year of his age. Mr. Gassiot was a merchant of London, but devoted his leisure to scientific research. In 1838 he was an active member of an electrical society, and for the remainder of his life devoted himself specially to the study of electrical phenomena. He was the author of several papers contributed to the "Philosophical Transactions" of the Royal Society of London. He was a munificent patron of science, and a helper of scientific men.

British Association Papers.—In his presidential address in Section D of the British Association, Dr. J. Gwyn Jeffreys vehemently attacked the doctrine of evolution, which he declared to be simply a "product of imagination. . . . I cannot," he said, "identify a single species of the Cretaceous Mollusca as now living or recent. All of them are evidently tropical forms. This question of identity depends, however, on the capability of hereditary persistence which some species possess; and although a certain degree of modification may be caused by an alteration of conditions in the course of incalculable ages, our knowledge is not sufficient to enable us to do more than vaguely speculate, and surely not to take for granted the transmutation of species. We have no proof of anything of the kind. Devolution or succession appears to be the law of Nature; evolution (in its modern interpretation) may be regarded as the product of human imagination. I am not a believer in the fixity of species, nor in their periodical extinction and replacement by other species. The notorious imperfection of the geological record ought to warn us against such hasty theorization. We cannot conceive the extent of this imperfection. Not merely are our means of geological information restricted to those outer layers of the earth which are within our sight, but nearly three-fourths of its surface is inaccessible to us, so long as it is covered by the sea. Were this not the case we might have some chance of discovering a few of the missing links which would connect the former with the existing fauna and flora. It is impossible even to guess what strata underlie the bottom of the ocean, or where the latter attained its present position relatively to that of the land. The materials of the sea-bed have been used over and over again in the formation of the earth's crust, and the future history of our globe will to the end of time repeat the past."

Miss A. W. Buckland, in a paper on "The Stimulants of Ancient and Modern Savages," said that the use of stimulants is almost universal. Among the lowest races the form of stimulant employed is now, as in ages past, some sort of root or leaf chewed for its strengthening and invigorating properties, such as the pitberry, recently discovered in use among nations in Central Australia, and the coca-leaf among the Indians of South America; but no sooner did the nations advance to the agricultural stage than they began to make fermented drinks from the roots of grains cultivated for food. Hence the beer of Egypt, which probably found its way with the wheat and barley of that land to the Swiss lake-dwellings, and over a great part of Europe, having been evidently known in Greece and

Rome at a very early period, while a similar liquor still forms the chief beverage of all African nations, being now, as formerly in Egypt, fermented by means of plants. In China and Japan rice was and is used to make wine or beer instead of wheat or barley or American maize. The sour milk or *koumiss* of the pastoral tribes of Central Asia, and the mead of the ancient Scandinavians, both reappear among the Kaffirs of South Africa. Palm-wine is used wherever palms flourish, but wine of the juice of the grape, although known in very ancient times, seems to have been confined to the civilized races of Western Asia and Egypt, extending later to Greece and Rome. The multitude of wines described by Pliny were, however, in almost all cases flavored with herbs or garden-plants for medicinal purposes. The conclusions to be drawn from the history of fermented beverages, as recorded by travelers, are, that the earliest stimulants were simply leaves and roots chosen by animal instinct, chewed, and found by experience to produce exhilaration and strength. The art of distillation, though probably known early in the Christian era, is comparatively modern, and was certainly unknown to savage races until "fire-water" was introduced, to their serious detriment, by Europeans.

In a paper on the "Shifting of the Earth's Axis," Mr. A. W. Waters pointed out how the unequal distribution of land and sea might be an agent for preventing the movements of elevation and depression of the land in one part of the globe balancing those in another, and also showed how similar movements in various localities would differently affect the pole. Any movement, such as submarine elevation, which displaces water, would spread it over the oceanic area; and the effect of this would, with the present configuration, be the same as if about one-twelfth of the weight had been added in the northern hemisphere along east longitude 45° 44′, namely, in a line passing by the entrance of the White Sea, over the Caucasus, and through the middle of Madagascar. As every submarine movement would create a force acting in this direction, there seems reasonable ground for thinking that the tendency would be for the shifting of the axis to take place near this line.

Simultaneous Contrast of Colors.—An incident in the life of Henry IV. of France finds its explanation in an experiment made by Chevreul. While yet Prince of Navarre, Henry IV. was playing dice with two courtiers a few days before the massacre of St. Bartholomew's-day. They saw, or thought they saw, on the dice spots of blood; and the party broke up in alarm. The phenomenon is explained by Chevreul by the law of simultaneous contrast of colors, and he illustrates this by experiment as follows: Seat yourself in a room so as to receive on the right side the sun's rays at an angle of 20° to 25°, the left eye being closed. On a table covered with gray paper and under diffuse light place two hen's-feathers, one black and the other white, distant 0.6 to 0.8 metre from the eye. After about two minutes, with the right eye in the sun's beams, the dark feather appears red and the white one emerald-green. After a few seconds the black feather of red color seems edged with green and the white feather seems of a rosy color. Now close the right eye and open the left. The black feather will be black and the white one white. The effect is evidently due to insolation: the black feather appears red because it reflects much less light than the white feather. From the law of simultaneous contrast of colors, the insolated eye seeing the green by white light, the black feather must appear of the complementary color of green, which is red.

Constitution of the Nebulæ.—Mr. E. J. Stone, in a paper read before the Royal Society, London, attempts to reconcile Huggins's discovery of bright lines in the spectra of nebulæ with the old view that nebulæ are irresolvable stellar clusters. The sun, he remarks, is known to be surrounded by a gaseous envelope of very considerable extent. Similar envelopes must surround the stars generally. Each star, if isolated, would be surrounded with its own gaseous envelope. These gaseous envelopes might, in the case of a cluster, form over the whole, or a part, of the cluster a continuous mass of gas. So long as such a cluster was

within a certain distance from us, the light from the stellar masses would predominate over that of the gaseous envelope. The spectrum would, therefore, be an ordinary stellar spectrum. Suppose such a cluster to be removed farther and farther from us, the light from each star would be diminished in proportion of the inverse square of the distance; but such would not be the case with the light from the enveloping surface formed by the gaseous envelopes. The light from this envelope received on a slit in the focus of an object-glass would be sensibly constant because the contributing area would be increased in the same proportion that the light from each part is diminished. The result would be that, at some definite distance, and all greater distances, the preponderating light received from such a cluster would be derived from the gaseous envelopes and not from the isolated stellar masses. The spectrum of the cluster would, therefore, become a linear one, like that from the gaseous surroundings of our own sun.

Duration of the Flight of Bees.—To determine the length of time that bees can continue to fly about, Dönhoff took some of those insects from a hive, just as they came out of the entrance-hole, and placed them under a glass bell at a temperature of 66° Fahr. First they ran hastily up and down the sides of the glass, and flew about in the jar. Their movements grew gradually slower, and after forty-five minutes they all sat quietly together, or moved very slowly and clumsily, and were unable to fly. On being allowed to crawl upon a pencil, and then thrown off, they fell down perpendicularly without moving their wings. On killing one or two, the honey-bags were found to be empty. The author then fed the others with a sugar solution, and after three or four minutes threw some of them into the air. They were now able to use their wings a little. A minute or two later they appeared to be as lively as ever. The author remarks that if the temperature is under 66° Fahr. the bees lose the power of flying even sooner, and recover it more slowly. With higher temperatures the power returns sooner. Dönhoff's conclusion from these observations is that the bee "loses the power of flying because it does not possess the necessary strength to be converted into muscular action, and that this strength returns to its system because in sugar it finds the necessary vital support."

Singing-Flames and Inaudible Vibrations.—"Singing-flames" are known to be sensitive to the faintest sounds, provided the rate of vibration of the latter is sufficiently high. But are they equally sensible to vibrations that are so rapid as to be inaudible? This question has been studied by Prof. W. F. Barrett, and the results of his experiments, as stated by him in a communication to *Nature*, will be read with interest. Prof. Barrett employed a flame produced by coal-gas contained in a holder under a pressure of ten inches of water, and issuing from a steatite jet having a circular orifice of 0.04 inch diameter; the height of the flame when undisturbed was just two feet, but it fell to seven inches under the feeblest hiss or the clink of two coins. On sounding the lowest note of a "Galton whistle," little effect was produced on the flame; a shrill dog-whistle produced a slight forking, but that was all. Raising the pitch of the Galton whistle, the flame became more and more agitated, until when Prof. Barrett had nearly reached the upper limit of audibility of the left ear, and had gone quite beyond the limit of the right, the flame was still more violently agitated. Raising the pitch still higher, till he had quite ceased to hear any sound, he was astonished to observe the profound effect produced on the flame. At every inaudible puff of the whistle it would fall fully sixteen inches, and give its characteristic roar, at the same time losing its luminosity, and, when viewed in a revolving mirror, presenting a multitude of ragged images, with torn sides and flickering tongues. Nor was this effect sensibly diminished by a distance of some twenty feet from the flame; even at fifty feet the effect was very pronounced.

Functions of the Cerebellum.—The researches and experiments of Flourens have been considered conclusive as to the coordinative function of the cerebellum in animal movements. That eminent physiol-

ogist removed the cerebellum from pigeons in successive slices, and found that, on cutting away the superficial layers of the organ, there appeared only a slight feebleness and want of harmony in the movements; but that when the deepest layers were removed the animal lost completely the power of standing, walking, leaping, or flying. Volition and sensation remained; the power of executing movements remained; but the power of coördinating those movements into regular and combined actions was lost. Flourens's experiments have been again and again repeated, always with the same results. But now the subject has been investigated anew by Ovsiannikoff, whose conclusion is that, even though the entire cerebellum be cut out, the faculty of coördination still remains. In one of his experiments a rabbit remained alive during two whole weeks after all the upper half of the cerebellum was cut out, nor did it lose its faculty of coördinating its movements after all the cerebellum was cut out until an effusion of blood produced this result.

Appearance and Habits of the Andaman Islanders.—The natives of the Andaman Islands are described by Surgeon-Major Hodder, of the British Army, as not exactly prepossessing in appearance, though not deformed and hideous, as has been stated. In height they vary from four feet nine inches to five feet one inch; they are extremely black, more so than the African negro, and some of them have "a dull, leaden hue, like that of a black-leaded stove." They are fond of dancing, have a strong sense of the ridiculous, are exceedingly passionate, are easily aroused by trifles, and then "their appearance becomes diabolical." The men go entirely naked, and the women nearly so. They cover their bodies with red earth, and, as ornaments, wear strings of their ancestors' bones round their necks, or a skull slung in a basket over their shoulders. They are tattooed all over their bodies; their heads are shaven, with the exception of a narrow streak from the crown to the nape of the neck. They rarely have eyebrows, beard, mustache, whiskers, or eyelashes. They are very fond of liquor and smoking; are short-lived and not healthy, not many passing forty years of age. Their language consists of few words, harsh and explosive, and chiefly monosyllabic. Almost their only amusement is dancing to a monotonous chant and the music of a rough skin drum, played by stamping with the feet. Their courtship and marriage usages are very simple. The male candidate for matrimony eats a sort of ray-fish, which gives him the appellation of "goo-mo"—bachelor desirous of marrying. The marriageable girls wear a certain kind of flower. The ceremony consists in the pair about to be married sitting down, apart from the others, and staring at one another in silence; toward evening the girl's father or guardian joins the hands of the pair; they then retire, and live alone in the jungle for some days. The only manufactures of the islanders are canoes, bows, arrows, spears, and nets. Of late years "homes" have been established for the Andamanese, consisting of large bamboo sheds, in which those who come in from the jungle put up, coming and going at will. They seem, however, to prefer the jungle, and the attempts made to cultivate their acquaintance do not appear to have been very successful.

The Ancient Ruins of Colorado.—A correspondent of the Worcester *Spy* writes as follows of certain highly interesting discoveries recently made by the Geographical and Geological Survey of the Territories conducted by Dr. Hayden:

"Prof. Hayden has given Southwestern Colorado a new interest, by discovering and describing the ancient ruins in that section and in Southeastern Utah. The fertile valley of the Animas was densely inhabited and highly cultivated by an enlightened race of people centuries ago. The ruins of the houses, corrals, towns, fortifications, ditches, pottery-ware, drawings, non-interpretable writings, etc., show that many arts were cultivated by these prehistoric people which are now entirely lost. Their houses were built of almost every kind of stone, from small bowlders to the finest sandstone.

"The finest of these ruins, and the nearest perfect, are situated about thirty-five miles below Animas City, in a large valley fifteen miles long by seven wide, on the west side of the river. This valley has

been covered with buildings of every size, the two largest being 300 by 6,000 feet, and about 300 feet apart. They are built of small blocks of sandstone, laid in adobe mud, the outside walls being four feet and the inside walls from a foot and a half to three feet thick. In the lower story are found port-holes a foot square. There are rooms now left, and walls for about four stories high are still standing. About the second story, on the west side, there was once a balcony along the length of the building. No signs of a door are visible in the outer walls, and the ingress must have been from the top, in the inside there being passages from room to room. Most of them are small, from eight by ten to twelve by fourteen feet, the doors being two by four feet. The arches over the doors and port-holes are made of small cedar poles two inches wide, placed across, on which the masonry is placed. The sleepers supporting the floors are of cedar, about eight inches thick, and from twenty to fifty feet long, and about three feet apart. A layer of small round poles was placed across the sleepers, then a layer of thinly-split cedar sticks, then about three inches of earth, then a layer of cedar-bark, then another layer of dirt, then a carpet of some kind of coarse grass. The rooms that have been protected from exposure are white-washed, and the walls are ornamented with drawings and writings. In one of these rooms the impression of a hand dipped in whitewash, on a joist, is as plain as if it had been done only yesterday. In another room there are drawings of tarantulas, centipedes, horses, and men.

"In some of the rooms have been found human bones, bones of sheep, corn-cobs, goods, raw-hides, and all colors and varieties of pottery-ware. These two large buildings are exactly the same in every respect. Portions of the buildings plainly show that they were destroyed by fire, the timbers being burned off and the roofs caved in, leaving the lower rooms entirely protected. The rock that these buildings were built of must have been brought a long way, as nothing to compare with it can be found within a radius of twenty miles. All the timber used is cedar, and has been brought at least twenty-five miles. Old ditches and roads are to be seen in every direction. The Navajo Indians say, in regard to these ruins, that their forefathers came there five old men's ages ago (500 years), and that these ruins were here, and the same then as now, and there is no record whatever of their origin."

Political Economy in Law-Schools.—M. Waddington, the French Minister of Public Instruction, has issued a decree making the study of political economy one of the subjects of examination for the degree of licentiate in all the schools of law. The innovation does not seem to give unmixed satisfaction to the French lawyers, who have at all times treated this science with contempt. The basis of the teaching of law, says their organ, is the text of the law; political economy is no branch of the law—it has no texts—it is not positive science—and is at most a conjectural art, or kind of literature, less amusing than others; and to require that men desiring to become magistrates and advocates should pass an examination in the theories of Malthus, Adam Smith, and Say, is absurd. The claims of economic science will, of course, find plenty of defenders; and indeed it would appear, in view of the complications and contentions which have arisen from the pending negotiation of a commercial treaty between France and England, that it might be well to have a knowledge of economic principles made imperative somewhere.

A New Remedy for Wakefulness.—To those whose brains will not subside when the time for rest has arrived, Dr. John L. Cook, of Henderson, Kentucky, proposes a very simple method of securing prompt and refreshing sleep without the aid of drugs. When the mind is active, the circulation in the brain is correspondingly active; we breathe more frequently, and the movements of the heart are more rapid and vigorous. On the other hand, when the mind is at rest, as in healthy sleep, the circulation in the brain is notably diminished, the heart-beats are less rapid and forcible, and the breathing is perceptibly slower. In the wakeful state the mind, as a rule, is intensely occupied, whence we may infer an increased amount of blood in the brain. Dr. Cook's suggestion is to withdraw a portion of this from the head, or lower the brain-circula-

tion, by taking deep and slow inspirations—say twelve or fifteen a minute. By this means the action of the heart will become slower and feebler, less blood is thrown into the brain, and very soon a quiet feeling, ending in sleep, is induced. As by a slight effort of the will any one may try this, we leave the question of its value to the test of actual experiment.

A New Optical Experiment.—Mr. William Terrill offers in *Nature* a new lecture-experiment for proving the compound nature of white light. This method is to arrange seven lanterns so as to project their several circles of light side by side on a white screen, then to color each circle by introducing slides of glass stained to imitate the seven colors of the spectrum (the proper intensity of color being found by trial); in this way are produced seven circles on the screen, colored from red to violet, and arranged side by side. Then by turning the several lanterns, so that the projected circles exactly overlap each other, one circle of white light is obtained, proving that the seven colors together make white light. The same effect can be produced with five colors only, if properly selected; and even two, the ordinary cobalt-blue and deep orange, will nearly do. If these two be made to partially overlap, the effect is very striking.

Dallinger's Studies of Minute Animal Forms.—The Rev. W. H. Dallinger, whose researches into the origin and development of minute life-forms have earned for him a distinguished place in the world of science, in a communication to the Royal Institution of Great Britain, gives a brief historical sketch of his labors in this field. Ten years ago Mr. Dallinger determined to work out, by actual microscopic observation, the life-history of some of the lowly and minute organisms which occur in putrid infusions. After four years of preparation, he commenced his work in conjunction with Dr. Drysdale, the plan needing two observers. Each set of observations was made continuous, so that nothing should have to be inferred. Very high powers were employed, and the largest adult objects examined were $\frac{1}{1000}$ of an inch, the smallest $\frac{1}{10000}$. Six forms altogether were selected, and their whole history was worked out. At first it was supposed that reproduction by fission was the usual method, but prolonged research showed that spores were produced. These were so small that a magnifying power of 5,000 diameters was needed to see them as they began to grow. The glairy fluid from which they developed seemed at first homogeneous, and it was only when growth set in that the spores became visible. All that could be learned about the origin of the glairy fluid was, that a monad larger than usual, and with a granulated aspect toward the flagellate end, would seize on one in the ordinary condition; the two would swim about together till the larger absorbed the smaller, and the two were fused together. A motionless spheroidal glossy speck was then all that could be seen. This speck was found to be a sac, and, after remaining still from ten to thirty-six hours, it burst, and the glairy fluid flowed out. The young spores that came into view in this were watched through to the adult condition. Bearing on the subject of spontaneous generation, this fact was learned, that, while a temperature of 140° Fahr. was sufficient to cause the death of adults, the spores were able to grow even after having been heated to 300° Fahr. for ten minutes. That there is no such thing as spontaneous generation of monads seems to Mr. Dallinger quite clear; and he is satisfied that, when bacteria are studied after the same manner, the same law will be found to hold good with them.

Influence of the Environment.—As a striking instance of the transformation effected in a race by changed conditions of life, *Das Ausland* quotes, from Khanikoff's "Memoir on the Ethnography of Persia," some observations on a colony of Würtembergers which in 1816 settled in the trans-Caucasus country, near Tiflis. The original colonists, we are informed, were "singularly ugly," with broad, square countenances, blond or red hair, and blue eyes. The second generation showed some improvement; black hair and black eyes were no longer rare. The third generation was so entirely altered that their Würtemberg descent was no longer visible, for now black hair and

black eyes were the rule, the face had gained in length, and the bodily habit, while nothing was lost in point of stature, was more slender and graceful. As the chastity of the women is not to be disputed, and as the colonists intermarry only among themselves—Khanikoff found only one case of a Würtemberger marrying a Georgian woman—the change in the race-characters can be attributed only to the influence of environment.

Extirpation of Injurious Insects.—A special meeting of the London Society of Arts was held a few weeks ago, to discuss measures for the extirpation of injurious insects. The paper for the occasion was by Andrew Murray, F. L. S., who advocated government interference as being indispensably necessary in the war against insect pests. He spoke of three principal modes of counteracting the ravages of insects, the first being county or district rotation of cropping. Most vegetable-feeding insects subsist on one kind of plant, as wheat, rye, potatoes, etc., and, if we take away their special pabulum, the race dies out. This we do by rotation of crops. The next means of extirpation recommended by Mr. Murray was burning the nidus in which the insect, in whatever stage, passes the winter; or using some substance, as Paris-green, hellebore, etc. There remains the last refuge of all invaded countries, namely, destroying the resources of the country before the invaders, so that they may perish for the want of food. This, Mr. Murray said, can rarely be necessary, but it would be, he thought, the proper course to follow, should the Colorado beetle gain a footing in England. The larvæ of the beetle would probably first appear in some potato-field near Cork, or Londonderry, Liverpool, or Glasgow; the instant this is perceived, the vines of the potatoes should be cut to the ground, and Paris-green scattered over the field.

Recent Observations of Stomach-Digestion.—A man in Paris, having an impermeable stricture of the gullet, was saved, by the operation of gastrotomy, from death by starvation. The patient's gullet is so completely blocked that when a small quantity of potassium ferrocyanide in solution is swallowed, no trace of the salt can be detected in the stomach; hence the gastric juice is absolutely free from any admixture of saliva. The food is reduced to a pulp and injected by a syringe into the artificial opening in the abdominal wall; it remains in the stomach for three or four hours; when milk is introduced, it disappears in from one and a half to two hours. The chyme does not pass gradually, as is commonly supposed, into the small intestine: during the first three hours after its introduction into the stomach its volume does not appear to diminish; then within about fifteen minutes, the entire mass is driven through the pyloric orifice. At the end of four hours the stomach is nearly always empty, but hunger does not begin to be felt till two hours later. The mean acidity of the gastric juice, whether pure or mixed with food, is equivalent to about 1.7 grain of hydrochloric acid per 1,000, never falling below 0.5, or rising above 3.2 grammes. The quantity of liquid present does not seem to exert any influence on the degree of its acidity, which is augmented by wine and alcohol, and lessened by cane-sugar. The gastric juice is more acid while digestion is going on than during the intervals of the process; its acidity seems always to be increased as digestion is drawing to a close.

Contents of a Utah Mound.—In the vicinity of Payson, Utah Territory, are six mounds, covering a total area of about twenty acres of ground. One of these mounds was opened last year, and the discoveries then made are recorded in a letter published in the *Eureka* (Nevada) *Sentinel*. First a skeleton of a man was found, which measured six feet six inches in length. In the right hand was a huge iron weapon, but this crumbled to pieces in handling. There was also found a stone pipe, the stem of which was inserted between the teeth of the skeleton. Near by was found another skeleton, not quite so large, supposed to be that of a woman. "Close by," writes the correspondent of the *Sentinel*, "the floor was covered with a hard cement, to all appearances a part of the solid rock, which, after patient labor and exhaustive work, we succeeded in penetrating, and found it was

but the corner of a box similarly constructed, in which we found about three pints of wheat-kernels, most of which dissolved when brought in contact with the light and air. A few of the kernels found in the centre of the heap looked bright, and retained their freshness on being exposed. These were carefully preserved, and last spring planted and grew nicely, though the field-insects seemed determined to devour it. We raised four and a half pounds of heads from these few grains. The wheat is unlike any other raised in this country, and produces a large yield. It is of the club variety—the heads are very long, and hold very large grains. . . . We find houses in all the mounds," he continues, "the rooms of which are as perfect as the day they were built. All the apartments are nicely plastered, some in white, others in a red color; crockery-ware, cooking-utensils, vases—many of a pattern similar to the present age—are also found. Upon one large stone jug or vase can be traced a perfect delineation of the mountains near here for a distance of twenty miles. We have found several millstones, used in grinding corn, and plenty of charred corn-cobs, with kernels not unlike what we know as yellow dent-corn. We judge from our observations that these ancient dwellers of our country followed agriculture for a livelihood, and had many of the arts and sciences known to us, as we found moulds made of clay for the casting of different implements, needles made of deer-horns, and lasts made of stone, and which were in good shape. We also find many trinkets, such as white stone beads and marbles; also small squares of polished stones, resembling dominos."

The Origin of Mineral Oils.—Mendelejeff, in a communication to the Russian Chemical Society, questions the current view as to the origin of mineral oils, namely, that they are the products of the decomposition of the fossil remains of organisms, and proposes a theory of his own. He calls attention to the possibility of the interior of our globe containing metallic masses of vast extent. If iron be the prevailing metal, and if it occur in combination with carbon, we have the material from which we can conceive the mineral oils to have been derived. Contact with water at a high temperature, and under great pressure, brought about by the upheaval or disruption of any of the overlying sedimentary strata, would result in the formation of metallic oxides and saturated hydro-carbons. The latter, permeating the porous sandstones of higher levels, condense there, or, by undergoing further change, become the marsh-gas of the "gas-wells," or are converted into unsaturated hydro-carbons. The invariable association of salt-water with mineral oil is not without its bearing on this interesting question. If the view recently advanced by Steenstrup that the curious metallic masses discovered by Nordenskjöld in Greenland, and generally held to be meteoric iron, be correct, and they are erupted matter and not of cosmical origin, their composition, which analysis has shown to be in a considerable degree carbide of iron, approaches nearly that of the material assumed by Mendelejeff as the source of the oil.

A Low Mammalian Brain.—At a meeting of the American Philosophical Society, as we learn from *The American Naturalist*, Prof. Cope exhibited a cast of the brain-cavity of a species of Coryphodon from New Mexico. This, according to Prof. Cope, is the lowest and most reptilian type of mammalian brain so far discovered, inasmuch as the diameter of the hemispheres does not exceed that of the medulla, which itself is as wide as the cerebellum. The latter is small and flat. The middle brain is the largest division, much exceeding the hemispheres in size, being especially protuberant laterally. The hemispheres contract anteriorly into the very stout peduncles of the olfactory lobes. These continue undivided to an unusual length, and terminate in a large bulbus, which is at first grooved above and then bifurcates at the extremity. The length of the hemispheres is $\frac{1}{18}$ that of the cranium, and their united bulk $\frac{1}{27}$ that of the hemispheres of a tapir of the same size. Their surface is not convoluted, and there is no trace of a Sylvian fissure. The region of the pons Varolii is very wide and exhibits a continuation of the anterior pyramids. The large size of the middle brain and olfactory lobes gives the brain as much the appearance of that of a lizard as of a mammal.

The Late Eruption of Mauna Loa.—The Rev. Titus Coan gives, in the *American Journal of Science*, a vivid description of the latest eruption of Mokua-weo-weo, the terminal crater of Mauna Loa, Hawaii. The eruption commenced between nine and ten in the evening of February 14, 1877, with great splendor. The summit of the mountain appeared as though melted, and the heavens seemed on fire. Vast masses of illumined steam, like columns of flaming gas, were shot upward to a height of 14,000 to 17,000 feet, and then spread out into a great fiery cloud. This continued through the night. In the morning the mountain was hidden by thick clouds, and the only symptoms of volcanic action were an occasional thud and a smoky atmosphere. Mokua-weo-weo had entered into a state of inactivity, but soon "a remarkable bubbling was seen in the sea about three miles south of Kealakekua, and a mile from the shore. Approaching the boiling pot, it was found emitting steam, and throwing up pumice and light scoria. This boiling," continues Mr. Coan, whose communication is dated Hilo, March 17th, "was active when we last heard. It is in deep water. On the island new fissures have been opened in the *pahoihoi*, which extend up to the higher lands, indicating the course of a subterranean lava-stream, that terminated in a submarine eruption—a new feature in our modern volcanic phenomena. About the time of this eruption beneath the sea, a tidal or earthquake wave of considerable force was observed along the coast of Kona."

Extraordinary Development of the Sense of Smell.—Dr. Maudsley, in his "Physiology of Mind," noticed elsewhere, speaking of the loss of one sense being followed by a notable increase in the functions of those which remain, in consequence of the greater attention given to them, cites the following instances as related by Dr. Howe in the "Forty-third Report of the Massachusetts Asylum for the Blind:" Julia Brace, a deaf and blind mute, a pupil of the American Asylum, had a fine physical organization and highly-nervous temperament. In her blindness and stillness her main occupation was the exercise of her remaining senses of smell, touch, and taste, so that through them she might get knowledge of all that was going on around her. Smell, however, seemed to be the sense on which she most relied. She smelled at everything which she could bring within range of the sense; and she came to perceive odors utterly insensible to other persons. When she met a person whom she had met before she instantly recognized him by the smell of his hand or glove. If it were a stranger she smelled his hand, and the impression was so strong that she could recognize him long after by again smelling his hand, or even his glove, if just taken off. She knew all her acquaintances by the odor of their hands. She was employed in sorting the clothes of the pupils after they came from the wash, and could distinguish those of each friend. If half a dozen strangers should throw each one his glove into a hat, and they were shaken up, she would take one glove, smell it, then smell the hand of each person, and unerringly assign each glove to its owner. If among the visitors there were a brother and sister, she could pick out the gloves by a similarity of smell, but could not distinguish the one from the other. This case furnishes a strong argument in support of the conjecture that a dog removed to a distant place finds its way home by following backward a train of smells which he has experienced.

Mr. Boyd Dawkins on Museum Reform.—Writing, in *Nature*, of the need of museum reform, Mr. Boyd Dawkins recognizes the existence of a "collecting instinct"—a desire to accumulate whatever strikes the fancy—and this instinct he declares to be almost universal among mankind, whatever their stage of intellectual development. The collections which result from this instinct bear the stamp of the individual who makes them. They are "museum units" which, like molecules, have a tendency to coalesce into bodies of greater or less size, and thus constitute museums. The organization of the latter is of high or low type, according as the units keep or lose the stamp of the individual, and have been moulded into one living whole, or are dissociated. They are highly organized and valuable if the parts are duly subordinated to each other and brought into a living relationship; they are

lowly organized and comparatively worthless if they remain as mere assemblages of units placed side by side without organic connection and without a common life. Mr. Boyd Dawkins regards most of the provincial museums in England as belonging to this lower type. His description of one or two of these collections is amusing enough, and worthy of being quoted entire; perhaps it will apply to some lauded collections to be found on this side of the Atlantic. "In one instance which occurs to me," writes Mr. Dawkins, "you see a huge plaster-cast of a heathen divinity surrounded by fossils, stuffed crocodiles, minerals, and models of various articles, such as Chinese junks. In another, a museum unit takes the form of a glass case containing a fragment of a human skull and a piece of oat-cake, labeled 'fragment of human skull very much like a piece of oat-cake.' In a third wax models are exhibited of a pound weight of veal, pork, and mutton-chops, codfish, turnips, potatoes, carrots, and parsnips, which must have cost the value of the originals many times over, with labels explaining their chemical constitution, and how much flesh and fat they will make." Museums of this low type "constitute a serious blot on our educational system, since they are worse than useless for purposes of teaching."

Size of Medicinal Doses.—One of the papers read at the last meeting of the American Medical Association was on "The Effects of Remedies in Small Doses." The author of this paper, Dr. John Morris, held that—1. The true physiological effect of remedies might best be obtained by the administration of small doses frequently repeated; 2. That medicines thus given are cumulative in their operation; 3. That the effect of remedies is greatly increased by combination, the manner of preparation, time and mode of administration, etc.; 4. That large doses of medicine frequently act as irritants; that they produce an abnormal state of the blood, as was evidenced by such conditions as narcotism, alcoholism, iodism, ergotism, bromidism, etc.; 5. That more special attention should be given at the bedside to the influence of remedial agents, to the end that greater certainty may be attained in the prescriptions.

Denationalizing Science.—Sir C. Wyville Thomson having called to his assistance, in working up the Challenger collections, a few foreign naturalists of eminence, Dr. P. Martin Duncan, President of the Geological Society, gives vent to his "feelings of disappointment" in a letter to Sir Wyville, and asserts that "a very large section" of British naturalists are in like manner pained by the way in which English workers have been passed over. Sir Wyville Thomson makes a dignified reply, in which he states that his endeavor had been to select first those who were generally regarded as *authorities* in special branches; and, second, those who could do the work assigned them within the allotted time. Where Englishmen fulfilled these conditions, Englishmen were chosen, because in that way a good deal of risk was avoided, in sending portions of the collections abroad. "Except for this consideration" (i. e., that of avoiding risk of losing collections), writes Sir Wyville, "I confess I saw and see no objection, but rather the reverse, to making a great work of this kind somewhat more catholic." Having thus mildly rebuked the rather despicable nationalism of Dr. Duncan, Sir Wyville gives a list of the naturalists employed in the work. It contains twenty-two names, all of them names of Englishmen, with six exceptions. He then begs the pardon of the Englishmen (if such there be) more eminent than Haeckel, A. Agassiz, Oscar Schmidt, Lyman, Gunther, and Claus, in their respective specialties of Radiolarians, Echinoidea, Sponges, Ophiuridea, Fishes, and Crustacea, but whom he has overlooked in favor of these foreigners. Notice has been taken of Dr. Duncan's letter by some of the most eminent scientific men in England, and a manifesto has been published deprecating national jealousies in science. This paper has received the signatures of Sir J. D. Hooker, Prof. Huxley, Dr. W. B. Carpenter, Mr. Darwin, Mr. St. George Mivart, and many other representative scientific men. *Nature*, in giving an account of this very unpleasant affair, calls attention to the catholic spirit manifested by the directors of the United States Gulf Stream Expedition, who distributed their materials for description among sixteen naturalists, of whom only four were Americans.

NOTES.

It has been found by Lechartier and Bellamy that zinc is constantly present in appreciable quantities in the liver of the human subject and of many lower animals. It also occurs in hen's-eggs, in wheat, barley, and other grains. These facts are of interest for forensic medicine.

It is to be hoped that the following lucid "directions for the formation of the letter *a*" are not a fair sample of the kind of instruction given in public schools throughout the United States: "The letter *a* is one space in height, three spaces in width; commence on the ruled line with a left curve, ascending one space, joined by an upper turn to a slanting straight line, descending to the ruled line joined angularly to a left curve, ascending one space, joined by an upper turn to a slanting line, descending to the rule joined by a base, turn to a right curve ascending one space."

Land that has been flooded by the sea is generally barren for years afterward. According to a German chemist the cause of this barrenness is the presence of an excess of chlorine salts; such land has a tendency to remain damp, and there is a formation of ferrous sulphate, which is highly injurious to plants. The land should be drained as quickly as possible, sown with grass or clover, and allowed to rest.

La Nature cites the great age of an orange-tree in the gardens of the Versailles Palace as an illustration of the longevity of that species of plants. This ancient tree, known as the "Grand-Connétable de François I.," and also as the "Grand-Bourbon," has now stood more than four hundred and fifty years. It is sprung from some seed of the bitter-orange sown in a plant-pot, at the beginning of the fifteenth century by Eleanor of Castile, wife of Charles III., King of Navarre. Several plants were produced from the same lot of seeds, and they were all kept in one box at Pampeluna till 1490. In 1684, more than two hundred years after being first grown from the seed, these orange-trees were taken to Versailles. The "Grand-Connétable" is in all probability the oldest orange-tree in existence; it is still in a very healthy state, and does not appear to suffer from the effects of age.

The coal of the Placer Mountains coal-mines in Arizona Territory possesses, according to Prof. Raymond, the hardness, specific gravity, fixed carbon, and volatile matter, of anthracite; it ignites with difficulty, but burns with intense heat. The supply is declared to be "inexhaustible."

A correspondent of the *Bulletin of the Nuttall Ornithological Club* narrates in that journal an instance of the persistency of a house-wren in nest-building. The nozzle of a pump in daily use was repeatedly found to be obstructed with sticks, which on investigation proved to be nest-building material taken in by a wren. One morning the bird was allowed to carry on its work for two hours, and then he had filled the pump so full that water could not be obtained until a part of the sticks had been removed. The nest was three times destroyed before the bird abandoned his work.

The belief that fish is specially adapted to feed the brain, and that fish-eaters are therefore more intellectual than the average, does not find much favor with Dr. Beard. He says that this "delusion is so utterly opposed to chemistry, to physiology, to history, and to common observation, that it is very naturally almost universally accepted by the American people. It was started," he adds, "by the late Prof. Agassiz, who impulsively, and without previous consideration, apparently, as was his wont at times, made a statement to that effect before a committee on fisheries of the Massachusetts Legislature. The statement was so novel, so one-sided, and so untrue, that it spread like the blue-glass delusion, and has become the accepted creed of the nation."

On the question whether birds hibernate, we have received from Mr. L. S. Abbott, of Reading, Michigan, a communication in which he states an observation made by himself, which goes to show that at least some birds do hibernate. While living in the backwoods of Ohio, our correspondent often noticed the swallows toward evening circling around the top of a sycamore-tree, in the hollow of which they would soon disappear. To determine whether the birds remained within the tree during the winter, Mr. Abbott had the tree cut down some time after the beginning of the cold season. The swallows were found within, clinging to the shell of the tree, stiff, motionless, and to all appearance in a state of suspended animation. The tree was hollow from the ground up, and the swallows were attached to the shell along its whole length.

A singular instance of heredity is recorded in a note from M. Martinet to the Paris Academy of Sciences. In 1871 several chickens on a farm held by the author were affected with polydactylism, having a supernumerary claw. This had been transmitted to them by a five-clawed cock raised on the same farm a year or two before. The type was propagated rapidly until in 1873 an epidemic ravaged the poultry-yard. At present, without any selection, this variety is very numerous; it has been propagated

among neighboring farms through the exchange of eggs by the farmers; if nothing interrupts its progressive increase, it promises ere long to be predominant. The peculiarity was not so perfect at first as it is now; the modification has been going on progressively.

A SQUARE metre of the wall of a surgical ward in the Paris Hospital la Pitié was washed—an operation that had not been performed during two years previously—and the liquid wrung out of the sponge was immediately examined. It contained micrococci in abundance, some micro-bacteria, epithelial cells, pus-globules, and ovoid bodies of unknown nature. The sponge used was new, and had been washed in distilled water.

ERNST HAEBERLEIN, to whom the world of science is indebted for the discovery of the first Archæopteryx, has now discovered another and more perfect specimen of the same curious reptile-like bird. As we learn from *Die Natur*, the new Archæopteryx has a head, which was wanting in the first individual discovered. Hence the hitherto undecided point whether the animal had the head of a bird or of a reptile can now be determined.

A NORWEGIAN engineer, Meinerk, has invented an ice-breaker for keeping far northern harbors open through the winter. The machine, as briefly described in the *Moniteur Industriel Belge*, is in form like a ploughshare, and is driven by two engines. Two centrifugal pumps throw a stream of water on the fragments of ice as they retreat behind the vessel, and drive them back into the channel made by the plough. In summer the plough may be converted into a powerful dredge.

IN a case of poisoning by colored stockings which is recorded in the *Lancet*, the patient suffered a severe itching of the feet with great pain, "like penknives darting into the feet and legs." The cuticle was raised in several places on the soles and sides of the feet, and there was a discharge of fetid pus. Chemical analysis proved that the stockings worn by the patient had been colored with coralline, which is known to produce poisonous effects on the skin.

THE following "death-notice" is translated literally from a Zurich newspaper:

"I communicate to all my friends and acquaintances the sad news that at 3 P. M. to-morrow I shall incinerate, according to all the rules of art, my late mother-in-law, who has fallen asleep with faith in her Lord. The funeral-urn will be placed near the furnace.

"The profoundly afflicted son-in-law,
"BRANDOLF-LICHTLER.

"ZURICH, *August 3d*."

A NEW malady of the grape-vine has made its appearance in Switzerland, where it has already done considerable damage in the vineyards. It is known as *blanc de la vigne*, or white-sickness of the vine, and is caused by the development of a mycelium which overspreads every part of the diseased vine. Recent researches, says *La Nature*, show that the cause of this infection resides in the props used for supporting the vines; the germs of the parasite find a shelter in the cracks of the wood. They may be destroyed by saturating the props with a solution of copper sulphate.

IN presenting to Mr. Walter Weldon the Lavoisier medal of the French Society for encouraging National Industry, Prof. Lamy stated that, at the date of the introduction of Mr. Weldon's invention seven or eight years ago, the total bleaching-powder made in the world was only 55,000 tons per annum, whereas now it is over 150,000 tons; and of this fully 90 per cent. is made by the Weldon process. By this process every sheet of white paper and every yard of calico made in the world have been cheapened.

THE city of Dunkirk, New York, possesses a Microscopical Society which, with a small membership and very slender resources, has already earned a name in the world of science. At a meeting of this society held in the early part of summer, Dr. George E. Blackham and Dr. C. P. Alling were reëlected respectively president and secretary of the society.

THE gorilla of the Berlin Aquarium is now at the Westminster Aquarium, London, "on a visit." His face is by Mr. Buckland pronounced to be very human, but as black as ebony; the nose is snub, the lips thick and heavy. During sleep, as we are informed by Mr. Buckland, "a pleasant smile every now and then lights up the countenance" of the animal.

PROF. PARLATORE, the eminent botanist, and for some time Director of the Museum of Natural History at Florence, died suddenly on Sunday, September 9th.

A NEW use has been found for dynamite, in the slaughter-house. Experiments made at Dudley, England, show that a small quantity of dynamite—a thimbleful—placed on the forehead of an animal and exploded, instantly causes death. In one experiment, two large horses and a donkey, unfit for work, were placed in a line about half a yard apart, the donkey being in the middle. A small primer of dynamite, with electric fuse attached, was placed on the forehead of each, and fastened by a string under the jaw. The wires were then coupled in circuit and attached to the electric machine. The three charges were exploded simultaneously, the animals falling dead instantly without a struggle.